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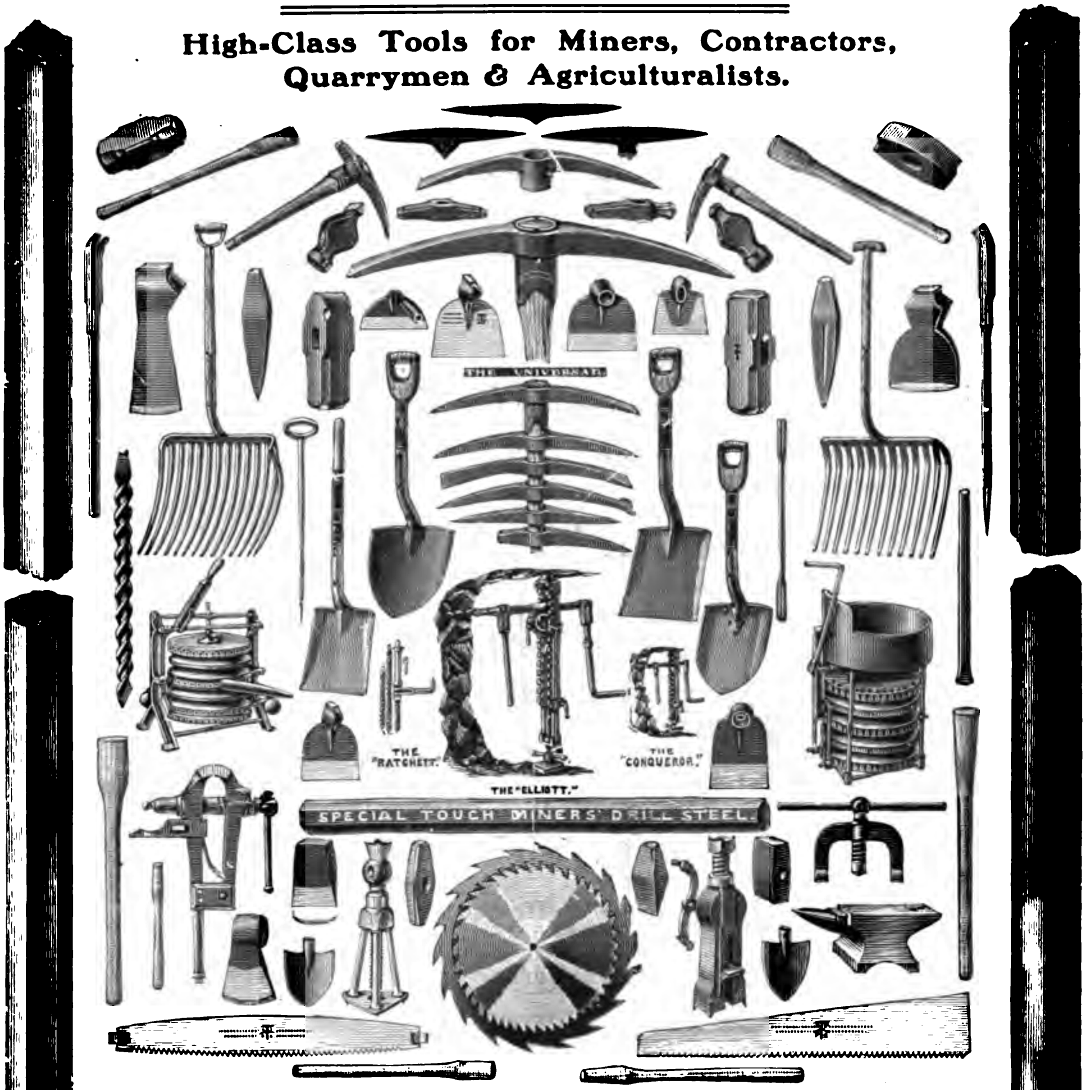
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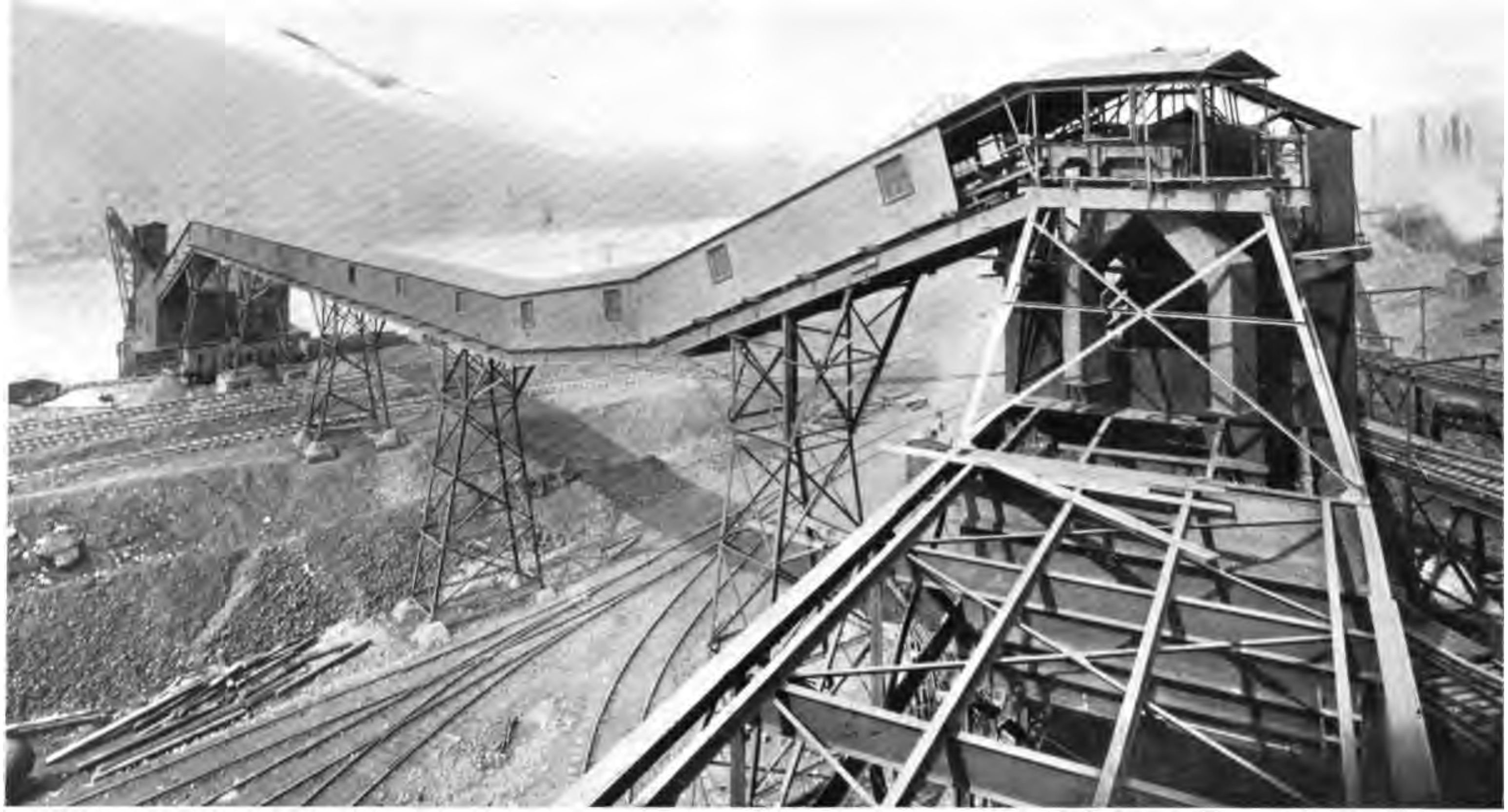
CONTENTS

No. 3. **SEPTEMBER, 1902.** **Vol. I.**

MODERN TRANSPORTATION OF ORES		Frontispiece
NAVAL NOTES Monthly Notes on Naval Progress in Construction and Armament. With Five Illustrations.	N. I. D.	251
THE DEVELOPMENT OF "WIRELESS" TELEGRAPHY—I. With Six Illustrations.	H. C. Marillier	260
SIR ANDREW NOBLE AND ELSWICK A Biographical Sketch. With Eight Illustrations.		266
IRON AND STEEL MANUFACTURE—II. Transportation of the Mineral from Mine to Furnace Stockyard. With Numerous Illustrations.	B. H. Thwaite, C.E.	275
MILLING MACHINES-III. The Universal Indexing and Dividing Heads, Tailstocks, and other Fittings. With Nine Illustrations.	Joseph Horner	287
THE EXAMINATION OF PATENT SPECIFICATIONS	James Swinburne, President of the Institution of Electrical Engineers, M. Inst., C.E., M.I. Mech. E., &c.	296
THE NEW ANCHOR LINER "COLUMBIA" With Sectional Drawing.		303
WORKSHOP PRACTICE A Résumé of Machine Tools, Cranes, and Foundry Matters for the Month. With Illustrations.		308
MODERN PRACTICE IN MILLING AND AMALGAMATING—I. With Illustrations.	Edgar Smart, A.M.I.C.E.	313
STANDING CHARGES With Numerous Diagrams.	Claude W. Hill, A.M.I.C.E., M.I.E.E.	323
ENGINEERING EDUCATION IN AMERICA	Frank Hix Fayant	327
ENGINEER OFFICERS IN H.M. NAVY	D. B. Morison	331
OUR MONTHLY RÉSUMÉ	The Editor	334
LOCOMOTIVE ENGINEERING NOTES		343
NOTABLE BRITISH PAPERS OF THE MONTH		346
REVIEW OF LEADING CONTINENTAL PAPERS		353
BOOKS OF THE MONTH		360
NEW CATALOGUES AND TRADE PUBLICATIONS		367



MODERN TRANSPORTATION OF ORES FROM THE VESSEL DIRECT TO THE FURNACE STOCKYARD.

An illustration showing the Robins' System conveying ore over several railway lines and an incline.—[*Vide* Article on "Iron and Steel Manufacture."]

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NAVAL NOTES.

MONTHLY NOTES ON NAVAL PROGRESS IN CONSTRUCTION AND ARMAMENT.

BY

N. I. D.

It is generally assumed that at this time of the year the Naval Estimates are in course of preparation by those officials who are not enjoying their holidays; and for several reasons special interest attaches to the Estimates to be presented to Parliament next year. In the first place, if general expectation be fulfilled, these Estimates should exhibit some mark of the mind of the new Director of Naval Construction. This in itself would direct particular attention to the votes which cover shipbuilding and design, but in addition there are questions connected with the struggle for supremacy between guns and armour, with the relative value of speed, and with the most efficient and economical method of generating steam, which cannot fail to give these matters additional importance. It is in taking into consideration the trend and bearing of each change in its relation to these questions that the difference lies between the professional aspect and the point of view of the public. It is, perhaps, only natural that what we may term the casual observer of naval affairs should be inclined, on learning that a new ship is to be built, to limit his regard to the more prominent characteristics, and to base his estimate of improvement or otherwise upon a comparison of these with the similar characteristics of other vessels of the same or like classes. The result of such casual and misleading comparisons must be familiar to all students of naval affairs who watch the daily and weekly press and the magazines intended for general reading. The outgrowth takes the shape commonly of articles in which, for instance, displacement alone is sometimes regarded as the essential factor for purposes of comparison between rival ships or rival fleets, sometimes gun power, and sometimes speed. It is, indeed, true that each of these attributes and others, such as coal endurance, may in turn become the chief factor of immediate efficiency, but a more intelligent appreciation will be formed by taking into account all the elements which contribute to the effectiveness of a ship of war, in relation to the duties required of the vessel. It may be as well then to summarise here the several qualities which in a greater or less degree are combined to make up what has been called battle-worthiness.

QUALITIES DESIRABLE IN SHIPS OF WAR.

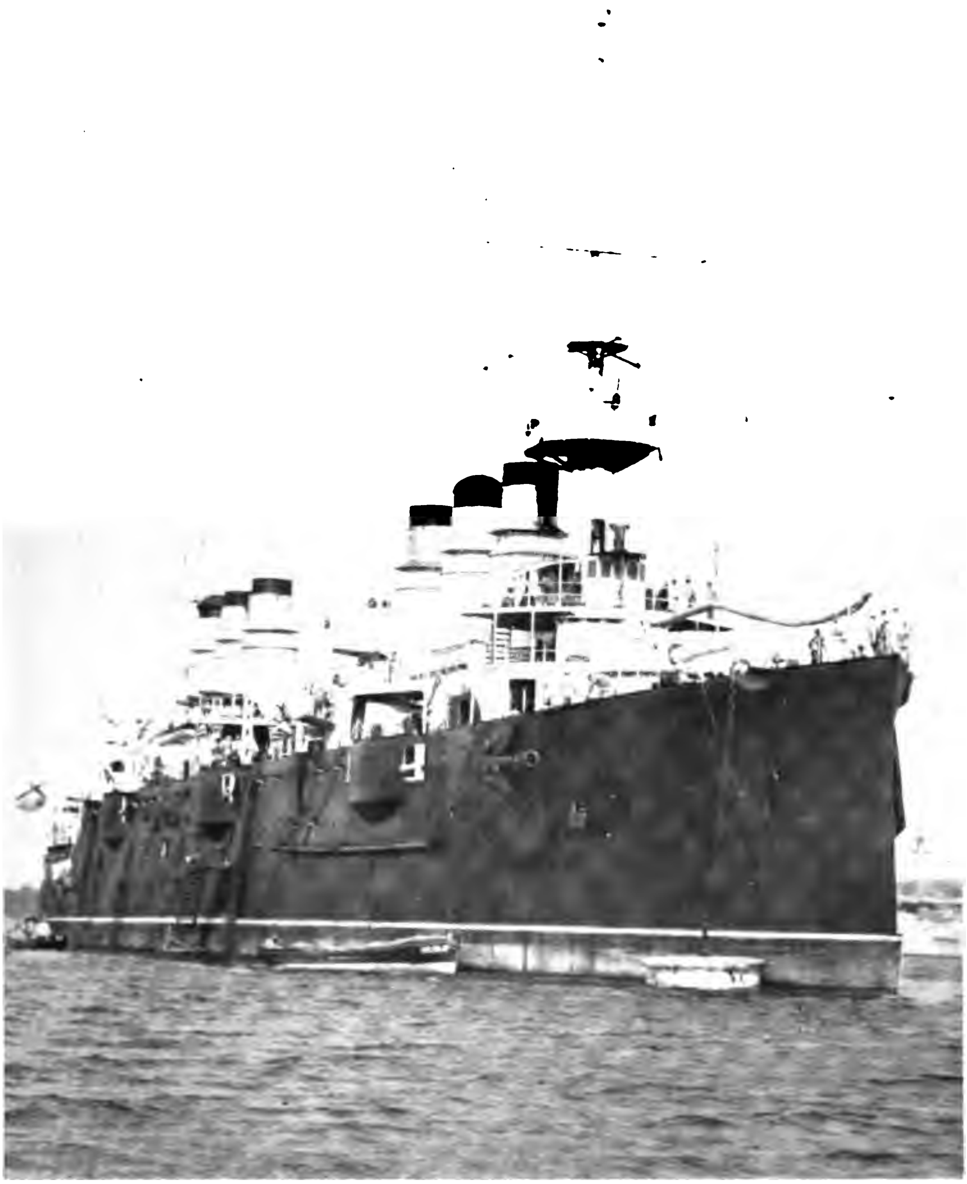
It will be readily understood that the importance of each of these qualities varies relatively to the duties which each ship may be called upon to perform, and that in our enumeration of them they are not placed in order of value as regards any particular class. *Displacement* is primarily a measure of the vessel's power to carry a certain weight, which weight may be distributed in various ways. It is possible to imagine two ships of precisely the same displacement, yet of entirely unequal value so far as battle-worthiness is concerned. The fleets of all the Powers may be made to yield examples demonstrating the misleading nature of comparison by displacement alone. *Offensive power* is a quality which may be given by guns, torpedoes or other weapons, or by several kinds together, and may be affected in a marked degree by the distribution of these weapons. The method of placing the guns in a ship may, and generally does, have an important bearing on her tactical use. *Defensive power* depends mainly on the resisting value of armour to projectiles and its extent and distribution in relation to the vulnerable and vital parts of the ship. *Locomotive power* includes speed, coal endurance, the economy and efficiency of the boilers and machinery, with the very important quality of being able to proceed rapidly from a position of rest to one of action; in other words, to raise steam with the least possible delay. *Handiness* involves satisfactory steering power, obedience to the helm, and steadiness in relation to the course, which is not to be found to the same extent in all vessels. As is now well known, every ship may be said to have her own idiosyncrasies in this connection, and until these have been discovered, the handiness of the ship cannot be developed to its fullest extent. *Sea-worthiness*, in itself a combination of elements, is, it goes without saying, essential to every ship. In a war vessel it includes, amongst other things, steadiness as a gun platform, and habitability for the crew in a reasonable measure. Last, but not least, there is "*the man behind the gun*," a comprehensive term, which may be said to include efficiency in numbers, in discipline, and in training, of the vessel's officers and men. As has been very truly said, it will be of very little account in the day of battle for the ship to have been well designed, for her engineers to have brought her to the place of action, and for her guns to be of the very latest model, if it be then found that her men cannot shoot straight and hit the enemy.

At another time we may consider the relative importance of the various elements we have described in those various classes of vessels whose duties differ as widely as do those of a battleship and a torpedo-boat. One word, however, may be said on the need for homogeneity in regard to the proportion of each element in each class of vessel. It should be obvious that it is useless in a group of vessels intended to manœuvre and fight together to make large differences in their respective powers, whether for offence, defence, locomotion or handiness. Any such differences must result in waste of power, and waste is abhorrent.

GREAT BRITAIN.

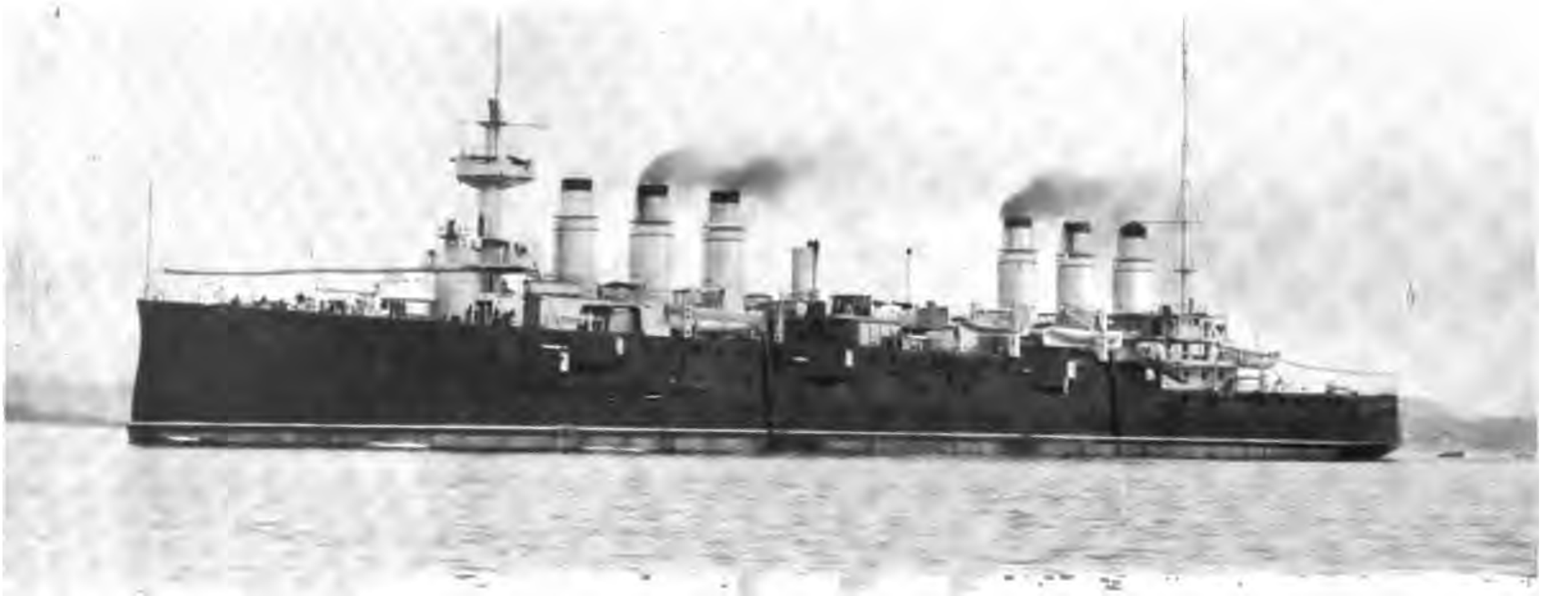
The two most important vessels in the programme of 1900-1901 were the battleships *Queen* and *Prince of Wales*. These vessels have not previously been described in these Notes, and, as they present some novel features, the following characteristics will be useful for purposes of comparison: The displacement is 15,000 tons, which is also that of the *Formidable* class. The length is 400 ft., breadth 75 ft., and mean load draught 26 ft. 9 in. The armoured protection, which is also similar to that in the *Formidable*, consists of a 9 in. belt, commencing from the after barbette and running forward to within 30 ft. of the bow, where it is continued right forward with a thickness of 2 in. of armour. At its after end there is a curved transverse bulkhead of 12 in., armour protection being continued to the stern by a deck 2 in. on the slope and 1 in. on the flat, which extends the entire length of the vessel. The belt itself is 15 ft. deep, and there is no bulkhead forward. The barbettes carrying the principal guns, two 12 in. 50-ton wire-bound breech-loaders in each, are protected by armour varying in thickness from 6 in. to 12 in., the hoods of the barbettes varying also in thickness from 8 in. to 10 in. The secondary armament of these vessels differs from that in the *Formidable* class; the former being provided with eight 7·5 in. quick-firing and ten 6 in. guns, the casemates for these pieces having 6 in. plates. As designed, these are the last British battleships to carry their secondary armaments in casemates. The machinery is practically identical for the two ships, and will consist of two sets of the inverted three-cylinder triple-expansion type, arranged to work twin

(*Continued on page* 255.)



FRENCH CRUISER "JEANNE D'ARC."

Displacement, 11,270 tons. Heaviest Gun, 7·6 in. Thickest Armour, 7·8 in. I.H.P., 28,500. Nominal Speed, 22 knots.



THE FRENCH CRUISER "JEANNE D'ARC."—ANOTHER VIEW.

(*Continued from page* 252.)

screws of 17 ft. 6 in. in diameter. The cylinders are 31·5 in., 51·5 in., and 84 in. in diameter respectively, with a 4 ft. 3 in. stroke. The number of revolutions when developing 15,000 h.p. is calculated to be 108 per minute, and when developing the contract power of 20,000 h.p. is estimated to give a speed of 19 knots. Steam will be given in the *Prince of Wales* by twenty water-tube boilers of the Belleville type, placed in three compartments, but in the *Queen* the type of boiler chosen is that of Babcock and Wilcox.

Armoured cruisers of the "County" class, of which mention has already been made in previous issues, are now coming to the front, the *Bedford* being the most advanced, having already undergone some of her trials at Devonport. The other vessels of the class are the *Kent*, laid down at Portsmouth, February 12th, 1900, and launched March 6th, 1901. This vessel is now being pressed forward. The *Essex*, laid down at Pembroke January 1st, 1900, was launched August 29th, 1901, and should soon be ready for her trials. The *Monmouth*, building by the London and Glasgow Shipbuilding Company, was launched on November 13th, 1901; the *Lancaster*, building at Elswick, on March 22nd, 1902. The *Cornwall*, building at Pembroke, is to be ready for launching in October. The *Suffolk*, laid down at Portsmouth, March 25th, 1901; the *Berwick*, building by Messrs. Beardmore; the *Cumberland*, by the London and Glasgow Company; and the *Donegal*, by the Fairfield Company—ten in all. There are also six vessels of the "County" class ordered to be built, but with slightly different design. These are the *Devonshire*, building at Chatham, and the *Antrim*, *Argyll*, *Hampshire*, *Carnarvon*, and *Roxburgh*.

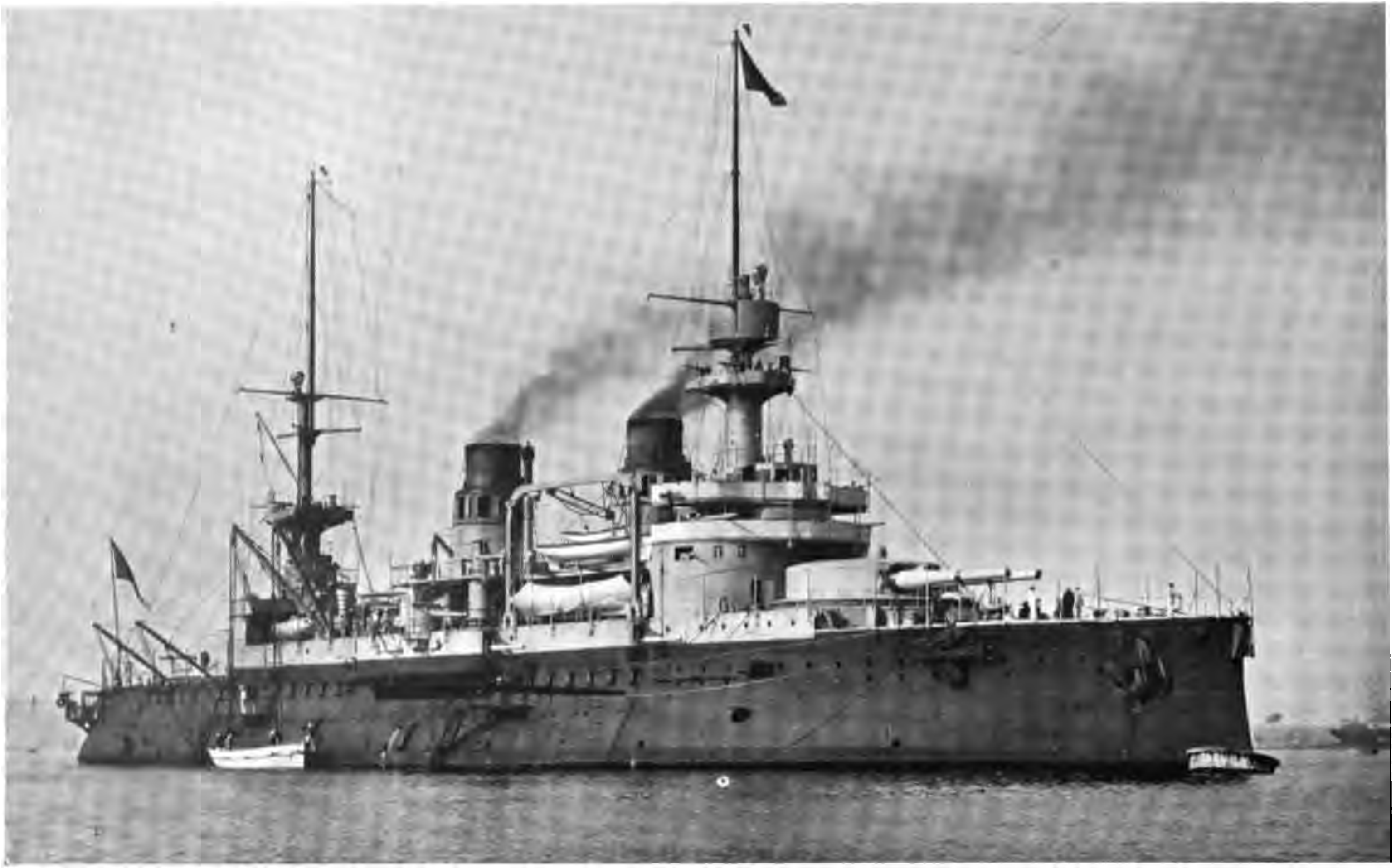
It will be remembered that in last year's programme reference was made to a new class of "scouts," and in connection with these vessels it was proposed to revert to the method used in the case of the torpedo-boat destroyers. The private shipbuilders of the country were asked to give the Admiralty the benefit of their creative ingenuity by submitting designs to fulfil certain stated conditions. These designs have now been received, and it is expected that before long the First Lord will make an announcement in regard to the distribution of the tenders for these vessels.

FRANCE.

Reference has already been made in these notes to the influence upon the progress of the French Navy of a change in the Ministry or of the Minister responsible for the Navy. M. Pelletan had hardly succeeded M. de Lanessen before indications were apparent that such a change was imminent. Of the six battleships authorised by Parliament, two were to be built, and the contracts had been signed with the Chantiers de la Gironde and the Chantiers de la Méditerranée for their construction. M. Pelletan has now notified the contractors that the financial state of the country does not encourage the hope that money will be available for these vessels. Whether he will be able to divert the amounts voted to other purposes has yet to be seen, but that delay in the completion of these vessels will result is fairly certain. In the meantime it is announced that the battleship *République* will be launched on September 4th, at Brest; and as by the previous arrangements the *Démocratie* was to take her place on the slips, we may then have an indication of how far M. Pelletan's ideas will prevail.

With the laying down of the two armoured cruisers, *Jules Michelet* and *Ernest Renan*, the naval programme of 1900 may be said to have been completed, so far as this class of vessel is concerned. The demand of the Superior Council was for three divisions of eight vessels each, but provision was only made for twenty-three. In these twenty-three cruisers there are eight different types, of which four were mentioned in the first issue of this magazine, the others being the *Dupuy de Lôme*, of 6,300 tons displacement; the *Amiral Charner*, of 4,700 tons; the *Pothuau*, of 5,300 tons; and the *Jeanne d'Arc*, of 11,200 tons displacement. The last-named were the heaviest vessels until the *Léon Gambetta* class was designed, and it is to this class that the *Michelet* and *Renan*, of 12,500 tons each, belong. These five vessels are estimated to cost £1,200,000 each.

On July 24th the *Gnôme* submarine was launched at Rochefort. This vessel is 135·8 ft.



FRENCH BATTLESHIP "SAINT LOUIS."

Displacement, 11,260 tons. Heaviest Gun, 12 in. Thickest Armour, 15·7 in. I.H.P., 14,500. Nominal Speed, 18 knots.

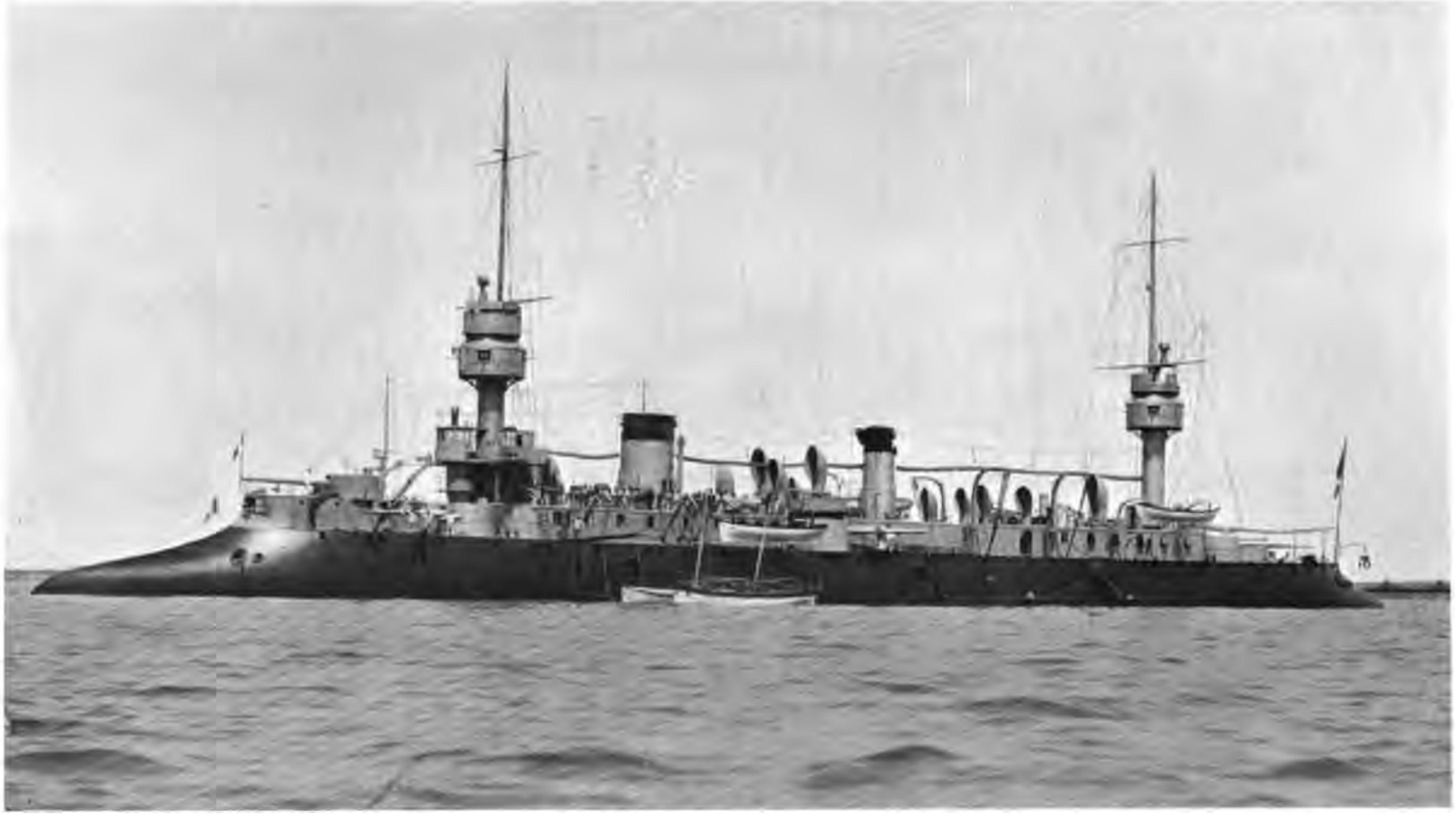
long, 9·5 beam, with a draught of 9·5 ft. Her displacement is 185 tons; she is expected to have 12·5 knots speed awash, and 9 knots when submerged. She is one of the largest class of submarines, her sister ships being the *Farfadet*, *Korrigan*, and *Lutin*.

GERMANY.

Last month we referred to the new type of German battleship, of which four are in hand. These are H., commenced at the Germania Yard, Kiel, on October 24th, 1901; J., which is in hand at Dantzig; K., which is to be built at the Vulcan Yard, Stettin; and L. at the Germania Yard. These are the largest battleships yet put in hand in Germany. The displacement is 13,200 tons, as compared with the 11,800 tons of the *Wittelsbach* class. The length is 398 ft. 6 in., the beam 72 ft. 10 in., and the draught 25 ft. 10 in., all of which dimensions show an increase upon those of the previous type of battleship. These vessels will have a complete belt of armour of 9 in., and 4 in. of Krupp steel with the armoured deck curved down to the lower edge of the belt for further protection. Above the side armour will be armour for the citadel, and above this again an armoured battery, in which will be mounted ten 6·7 in. quick-firers. Four similar guns will be mounted in the citadel in turrets at the four corners, while two barbettes at either end will mount two guns of 11 in. calibre each. These gun positions will be protected with 10 in. of Krupp steel, and the bases of both barbettes and turrets will be well protected. Of six torpedo tubes, five will be submerged. The boilers of these ships will comprise a proportion both of the cylindrical and water-tube types, and the engines are to be capable of developing 16,000 h.p., giving a speed of 19 knots. The normal coal capacity is 800 tons. Six torpedo-boat destroyers have been ordered of Schichau. These vessels, to be numbered 114 to 119, will be of 350 tons displacement, 6,000 h.p. and 28 knots speed.

RUSSIA.

Reference was made in the July issue to the battleship *Orel* of the new programme, building at Galerny Island. This vessel, begun on June 2nd, 1900, was launched on July 20th, when about 56 per cent. of the work on her had been completed. Her length will be 398 ft. 11 in., beam 76 ft., draught 26 ft., displacement 13,516 tons. The engines, of 15,800 h.p., will be supplied by twenty Belleville boilers and give a speed of 18 knots. The armament comprises four 12 in., twelve 6 in. quick-firing, twenty 2·9 in., and several smaller guns, besides four torpedo tubes, two of which are submerged. Some of her armour is to be supplied by the Carnegie Steel Company, and a recent trial was made of test plates in the United States. These plates were of 4 in., treated by the Krupp process. A 4 in. gun and a Wheeler Sterling projectile of 33 lbs. were used for the trial. Four rounds were fired, the last with a capped projectile. The striking velocity of the four rounds was respectively 1,837 ft. sec., 1,845 ft. sec., 1,830 ft. sec., and 1,834 ft. sec.; and the energy was 771 ft. tons, 778 ft. tons, 766 ft. tons, and 769 ft. tons. The last made a clean hole through the target. The battleship *Kniaz Potemkin Tavrichesky*, which was begun at Nikolaiev on December 7th, 1897, and launched on October 9th, 1900, has now been sent to Sebastopol to be completed. The length of this vessel is 378 ft. 6 in. over all, and at the water-line 371 ft. 2 in. Her beam, 73 ft; draught, 27 ft.; displacement, 12,600 tons. Steam is provided by Belleville boilers, one group heated by coal and the other by petroleum. Her coal capacity is 760 tons, and petroleum storage 580 tons. The engines, of 10,600 h.p., are to give her a speed of 16 knots. Her armoured belt extends 237 ft. amidships, having a thickness of 9 in., and is continued to the ends fore and aft with a thickness of 3 in. Over this is a strip 6 in. thick, extending for a distance of 156 ft. amidships, and above this again another strip 5 in. thick extending for a length of 168 ft. Bulkheads close in the batteries, the armour being respectively 7 in., 6 in., and 5 in. in thickness. Two armoured decks are provided, the maximum thickness on the sloping part of the lower one being a little less than 2 in. All the armour used is treated by the Krupp process and made in Russia. The armament consists of four 12 in., sixteen 6 in., fourteen 2·9 in., and some smaller guns, the larger calibres being of the Canet type.



FRENCH CRUISER "DUPUY-DE-LÔME.'

Displacement, 6,300 tons. Heaviest Gun, 7·6 in. Thickest Armour, 4·7 in. I.H.P., 14,000. Nominal Speed, 20 knots.

Photo by Carl Speck, Kiel.]

THE GERMAN CRUISER "PRINCE HEINRICH."

Displacement, 8.868 tons. Heaviest Gun, 9·4 in. Laid down, December 1st, 1898. Launched, March 22nd, 1900. Thickest Armour, 4 in. I.H.P., 15,000. Nominal Speed, 20 knots.

On the same day that the *Orel* was launched, the Czar performed the ceremony of the *zakladka* on the new Russian cruiser *Oleg*. This vessel was begun on November 21st, 1901. Her length will be 433 ft. 10 in., beam 54 ft. 5·5 in., draught 20 ft. 7 in., and displacement 6,675 tons.

UNITED STATES.

The battleship programme of the United States contains many interesting features. It may be said to have begun with the *Kearsarge* and *Kentucky*, launched in 1898, and displacing 11,540 tons. In these vessels was introduced the system of superposed turrets, four 8 in. guns being coupled in two smaller turrets upon the top of the large turrets for four 13 in. guns. This system was not applied in the *Alabama*, *Illinois*, and *Wisconsin*, of 11,525 tons, nor again in the *Maine*, *Missouri*, and *Ohio*, of 12,400 tons, which belong to the programme of 1897-98. For the three ships however of the 1899 programme, the *Georgia*, *New Jersey* and *Virginia*, and the two ships of the 1900 programme, the *Rhode Island* and *Nebraska*, the superposed turret was again adopted. These vessels will displace 14,600 tons, and their armament will comprise four 12 in., eight 8 in., twelve 6 in., and some thirty smaller guns, which may be compared with the armament of our *King Edward VII.* class, consisting of four 12 in., four 9·2 in., ten 6 in., and about twenty-four smaller guns. The speed of the United States vessels will be about half a knot more than that of our new ships, the protection and coal capacity being about the same. As was said last month the programme of the present year includes two battleships of not more than 16,000 tons each, which may indicate that the system of superposed turrets is again to be abandoned. If we include the *Indiana*, *Iowa*, *Massachusetts*, *Oregon*, *and Texas*, with the fifteen ships just mentioned, we have the twenty battleships recommended by the Naval Policy Board of July, 1890.

The same Board recommended that there should be sixty cruisers in the fleet, and so far as armoured vessels of the class are concerned there are now thirteen completed, building, or projected.

THE DEVELOPMENT OF "WIRELESS" TELEGRAPHY.

BY

H. C. MARILLIER.

I.

THERE is a tendency, one that is inseparable from all epoch-making developments, to suppose that "wireless" telegraphy is a new thing, suddenly originated and offered to the world by a discoverer. The Röntgen rays, so called from the distinguished German professor who first discovered them, were exceptional, in that they had not been expected or predicted by theory, and consequently for a time they were not understood; but with our present subject there was no room for a surprise. Theory in that case preceded experiment, and the waves were being actually looked for by several experimenters.

MAXWELL'S THEORY.

For the basis of modern telegraphy without conducting wires it is not necessary to go back further than the memorable researches of Professor James Clerk Maxwell, of Cambridge, who in the early sixties demonstrated by mathematical and physical reasoning that an electric oscillation should send out electromagnetic waves which are of the same order as waves of light and heat, and, in fact, form a continuous sequence with them, differing only in respect of their lower range of frequency and greater length, which prevent their recognition by our senses. Electricity, magnetism, light and heat are, in fact, merely abstract names for different manifestations of the same phenomenon, to which may be added a further series of effects due to waves of higher frequency than those of light, the photo-chemical, or ultra-violet, and the already mentioned Röntgen rays.

THE HERTZ EXPERIMENTS.

Maxwell's belief had for a time few followers outside this country, the Germans especially being wedded to a rival theory of action at a distance. It was, nevertheless, left for a German, the lamented Heinrich Hertz, who died in 1894, to put the crown to Maxwell's work by confirming experimentally the existence of such radiations and their behaviour in a manner like the visible ones of light. By means of suitable receivers, or "resonators," he intercepted and measured their length and frequency; showed that they could be reflected and deflected by metal surfaces, refracted by certain media, concentrated by lenses, impeded by glass or water, and even polarised. He proved, in fact, that they behaved in all respects like a beam of light, having, moreover, the same velocity of transmission, viz., 186,400 miles per second. Only in the frequency and amplitude of their vibrations, which govern the physical effects they are capable of producing, is there any essential difference. The form of detector employed by Hertz in his experiments to intercept the invisible rays he was dealing with was a split metal ring, with the ends capped by two small balls which nearly touched. When a spark from a Leyden jar or oscillator was allowed to start vibrations in the neighbourhood of such a ring, surging currents were set up in it corresponding in duration to the length of the disturbance, and these manifested themselves by a secondary spark between the little balls.

Hertz's results, published in 1888, attracted wide attention, especially amongst those who had already been working at Maxwellian waves, of whom the late Professor Fitzgerald, of Dublin, and Dr. (now Sir) Oliver Lodge were amongst the most prominent. The chief outcome of their labours and others, since then, has been an immense improvement in the sparking apparatus used to start the vibrations, and a multiplication of suitable forms of detectors, many of them of greatly increased sensibility. These two pieces of apparatus form the essential elements in modern "wireless" or—as the correct Germans prefer to call it—"spark" telegraphy, and their development will be dealt with separately.

SIR OLIVER J. LODGE, D.SC., F.R.S., LL.D.,
Principal of the University of Birmingham.

"WIRELESS" TELEGRAPHY A BYE-ISSUE.

Meanwhile it is necessary to remark that telegraphy across space was only a bye-issue of the researches with Hertzian waves; Hertz himself paid no attention to it, though the application was obvious, and of his successors who did, most were concerned at first with the scientific rather than the practical aspect. Nevertheless, the question of signalling across space without connecting wires had arisen at a fairly early date, and electrical workers had been engaged upon it. Speaking generally, the earliest experiments had no reference to ætheric vibrations whatever, but were attempts to utilise the known leakage of electric currents through the earth and through water, to communicate between more or less distant points.

PRIMARY FACTS.

A diagram will explain this system clearly. A and B are metal plates sunk in the water at two points on one side of the river Thames, and connected by an insulated wire. C and D are corresponding plates also connected on the opposite side. If a current is passed through the wire A B it uses the earth, and more particularly the water, as a return circuit, spreading out in the manner shown by the dotted lines. A portion of the current spreads as far as the metal plates C and D, and passing into the wire which connects them, will give faint, but perhaps intelligible, signals. When a storm once destroyed the cable connecting the island of Mull with the mainland the telegraphists actually used this method of signalling, the ends of the overhead land wire on the island being dipped into the sea, whilst at Oban a wire a mile and a-half long was laid along the shore and dipped into the sea in a corresponding manner. Communication was thus kept up for over a week across a strait two miles wide. Experiments of this kind were made by Morse, the father of telegraphy, as far back as 1842, and were continued down to 1894, the introduction of the Bell telephone in 1877-8 providing experimenters with the most sensitive receiver that could possibly be devised for making small currents perceptible, and giving a considerable impulse to their attempts.

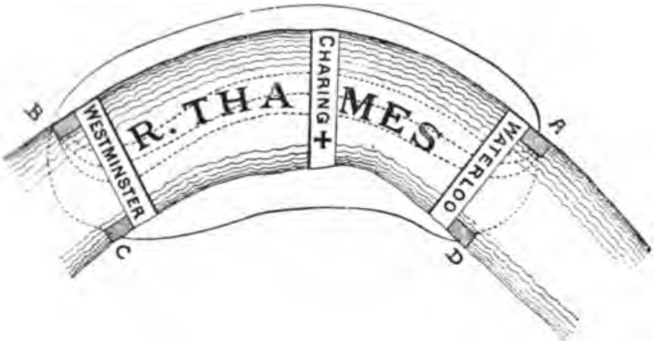


DIAGRAM SHOWING EARTH CURRENTS.

EARLY EXPERIMENTS.

Under the influence of this renewed activity, Mr. (now Sir William) Preece conducted a long series of experiments between the Isle of Wight and the mainland, and later at Penarth, and across the Kilbrennan Sound, between Kintyre and the Isle of Arran. The distances traversed in this way were from four to six miles, to accomplish which land-lines of several miles in length were required. The system in fact was far from economical, and is chiefly interesting nowadays from a historical point of view. Perhaps the most successful attempt to cope with its possibilities was that made by Dr. Rathenau and Professor Rubens in 1894, across the open waters of the Wannsee, near Potsdam. Using sunk metal electrodes and a base-line about 550 feet long, these experimenters succeeded in signalling three miles, the current generator being a battery of 75 accumulators with a rotating interrupter. The receiver was a telephone, from which messages were read off in the usual dot and dash code. Earth currents, as a mode of communication, are employed in one of the latest competing systems of "wireless" telegraphy (the Orling-Armstrong) as well as in the earliest experiments, and will be referred to once more in this connection in a subsequent article.

ELECTRO-MAGNETIC INDUCTION.

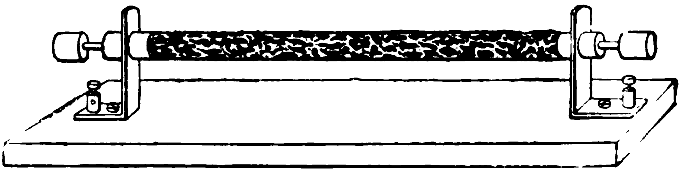
A more promising method of signalling across a distance without conducting wires appeared, and still appears, to be offered by the phenomena of electro-magnetic induction. A varying or alternating current in a wire circuit has the property of inducing a corresponding current in another circuit near it. This is the principle of the ordinary transformer, in which, however, the two circuits are packed as closely together as they can be and provided with a metallic core to render the losses of transformation as small as possible. In telegraphy the object is to get the circuits as far apart as possible, and yet preserve economy, which can only be done to a limited extent without the use of special devices. The most important of these are associated with the name of Sir Oliver Lodge, whose work, dating from about 1889, will be described presently. Practical experiments with induction were also carried out by Sir William Preece at several points and in several ways in 1893, and his results were summarised in a paper read by him before the Chicago Congress. In many of his experiments earth-completed circuits were used, and there is little doubt that earth conduction currents as well as induction played a part in the performance. On one occasion at least, however, two quarter-mile squares of insulated copper wire were used, in such a way as to preclude earth currents, and with these, by means of rapidly-interrupted or vibratory currents, signals were transmitted inductively over a distance of about a quarter of a mile.

ACCIDENTAL CLUES.

The extraordinary range covered by certain accidental occurrences, as when signals passing in a Langdon-Davies phonopore circuit, with very high frequency currents, have caused disturbance in telephones 100 miles away, gave reason to suppose that much might be done with properly constructed apparatus; and it is on record that an offer was made, if £10,000 were forthcoming, to establish communication by this method with the Cape. Probably the main reason why nothing on a large scale was attempted was that just about that time the method of signalling with Hertz waves came into prominence and eclipsed it.

AERIAL ELECTRIC WAVES.

It would not be easy to determine who first discovered the action at a distance of aerial electric waves. Joseph Henry, the Faraday of America, had got signals between the attics and the cellar of his house, by means of sparks, before Maxwell had even propounded his theory; and other old records of similar kind might be instanced; but their significance remained unrecognised. After the publication of Hertz's and Lodge's experiments many such observers came forward with recollections of facts bearing on the subject which had puzzled them at the time, or which they had taken note of. Probably the most important of such old observations (though they were never published) were those of Professor Hughes, the inventor of the microphone, which to this day remains one of the most sensitive devices for detecting Hertzian waves. Long before Hertz had published his researches, or begun them, Professor Hughes was working at Hertzian waves, trying to determine their nature and to employ them practically for messages. In 1878 he described, in a paper read before the Royal Society, "a tube filled with loose filings of zinc and silver," which served as a detector, and which was the origin of the Branly coherer of twelve years later. In 1880 he demonstrated the actual transmission of signals to the President of the Royal Society, Mr. Spottiswoode, and the two hon. secretaries, Professor Huxley and Professor G. Stokes. The last-named gentleman, however, was unwilling at that date to accept the phenomena as due to aerial waves, and attributed them to electromagnetic induction, whereupon Professor Hughes became discouraged and dropped the subject. After Hertz, with his far more masterly researches, had solved the entire problem in 1887-9, Professor Hughes felt, he says, in a letter to the *Electrician* in 1889, "that it was too late to bring forward his previous experiments, and through not publishing his results and the means employed, he was forced to see others re-make the discoveries he had previously made as to the sensitiveness of the microphonic contact, and its useful employment as a receiver for electric aerial waves."



AN EARLY FILINGS COHERER.
(From Lodge's "Work of Hertz." Electrician Publishing Co.)

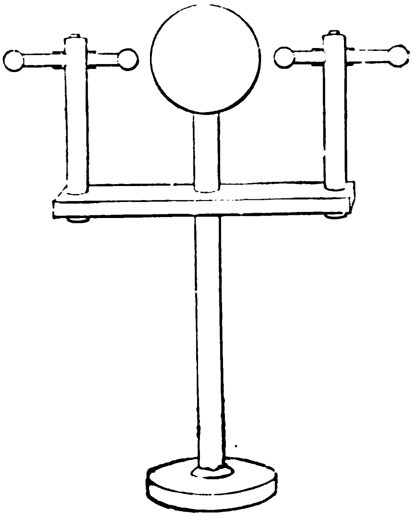
DR. LODGE'S EXPERIMENTS.

A more fruitful series of experiments was that of Sir Oliver Lodge, already mentioned, at Liverpool. Lodge had been working at oscillatory discharges and electro-magnetic waves before Hertz, and had partially anticipated Hertz's discoveries. He obtained evidence of waves running along wires, starting from an oscillating or spark circuit, and measured their length. His first successful signalling results, however, were published in 1889, and were carried out with what he called "syntonic" circuits—closed circuits containing Leyden jars, and tuned by means of a sliding resistance in such a way that the receiving circuit is far more sensitive to induction from the transmitting system than would ordinarily be the case. The first application of the "coherer" principle formed a part of this experiment, the overflow spark from the syntonic Leyden jar at the receiving end taking place between two balls placed so close together that after the passage of the spark they remained in actual contact. This cohesion of bodies following a spark is an old discovery, due perhaps to Guitard, who in 1850 found that particles of dust adhered to each other in the presence of an electrified body. The massing of rain-drops during a thunderstorm is attributable to the same cause. While the two balls were in contact no further spark could pass, and so in order to repeat the signalling action it was necessary to have some tapping apparatus to make them come apart. Such an apparatus, acting automatically, formed part of Dr. Lodge's original 1889 experiments, and consisted simply of an electric bell and battery in the circuit. The bell was placed on the same platform as the stand containing the balls, and its vibration every time the balls allowed a current to pass was sufficient to break the cohesion. A sort of make-and-break action was thus set up between the coherer and the bell. "Coherer" was Dr. Lodge's own term for the apparatus. Another form which it took in his experiments was a point in contact with a spring, which recalls the microphone joint, and forms a highly sensitive arrangement.

THE BRANLY COHERER.

M. Edouard Branly, of Paris, however, discovered in 1890 the property of metallic powders, filings, etc., to act as detectors of spark waves ; and his form of coherer, which down to a recent date has held the record for sensibility, was finally adopted by Dr. Lodge for work with Hertzian waves, in preference to any other. The first notice of Branly's coherer, in which its action was described but not explained, appeared in *Comptes Rendus*, November 24th, 1890, and may be summarised as follows: A glass tube, containing metal filings between two metallic conductors, is placed in circuit with a Daniell's cell and a galvanometer. Owing to the high resistance of the filings no current can pass. As soon as a spark passes in the neighbourhood of the tube from a Wimshurst machine, or Ruhmkorff coil, the resistance of the filings drops from several million ohms to 2,000, or even to 100 ohms, and a current is registered on the galvanometer. The action had been shown to take place at 20 metres distance, through opposing walls or floors. M. Branly made several further discoveries of the same nature, with variations of his material, but although the credit for the fundamental discovery is his, most experimenters have adapted his coherer in their own way to suit their own ends. Dr. Lodge applied to it his automatic tapping arrangement already described, without which its receptive properties come to an end after the first impulse. He also improved its sensitiveness by placing the grains of metal in a vacuum, or occasionally in hydrogen. A further addition to the receptive properties of the Branly coherer, first employed by Lodge in his earlier forms, is the use of metal streamers, or "antennæ," to intercept a greater range of vibrations, and also to tune the circuit of the receiver. Finally, it was Dr. Lodge, in conjunction with his co-worker, Dr. Alexander Muirhead, the well-known telegraph expert

DR. EDOUARD BRANLY.

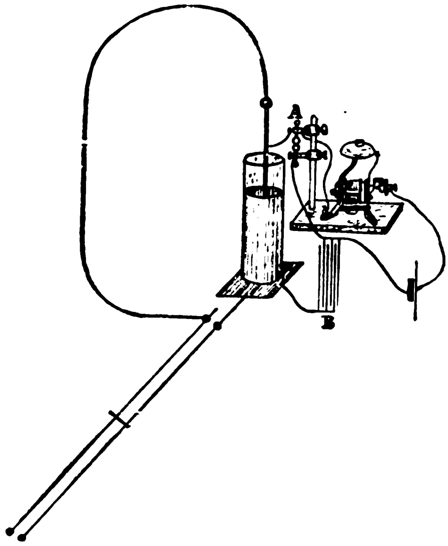


LODGE'S EARLY RADIATOR.
(From "The Work of Hertz." Electrician Publishing Co.)

who first applied the automatically tapped coherer to convey dot and dash signals, sent as interrupted Hertz waves, to a telegraph instrument. He, in fact, used it as a relay to make the distant oscillations operate an electric bell, a Morse sounder, or a siphon recorder. His transmitter or radiator was an arrangement shown in outline, of one or more large spheres between two knobs, which has since been considerably improved by Professor Righi, of Bologna, who interposed a layer of oil between the two central balls, thus keeping their surfaces clean and assisting in the production of sharp snappy sparks. Righi's oscillator, connected with a 10 in. induction coil, is the instrument most generally employed in transmitting Hertz waves over moderate distances.

SYNTONISING.

An account has been given of Lodge's special contributions to telegraphy with Hertz waves, because some of them have since proved to be essential elements of success, and have been adopted by later exponents; but Lodge's own preference seems to have lain throughout in the direction of magnetic induction, rendered practicable by the special devices already referred to. Of these the most important is his method of "syntonising," or tuning the transmitting and receiving circuits so that the inductive effect is enormously magnified. In a paper read before the Institution of Electrical Engineers in December, 1898, Sir Oliver Lodge gave a full description of this system and of his earlier experiments with it. Instead of Leyden jars, he placed in his two circuits condensers of large capacity, syntonised to respond to vibrations of the same period. In the transmitting circuit was a small alternator, giving a frequency of vibration of 384 per second (in place of the million or so appropriate to Leyden jars), so that the resulting waves came within the region of audible sound. The receiving circuit, therefore, contained no coherer, but simply a telephone, placed in shunt to the condenser. The circuits were insulated wire enclosures embracing about 400 square yards, distant two miles apart. Owing to the initial difference of potential between the terminals of the receiving condenser, the effect of sympathetic oscillations is cumulative, and may produce an electromotive force of many thousand volts, capable of bursting the condenser. The action is compared by Sir Oliver Lodge mechanically to that of a heavy truck pushed backwards and forwards on a pair of rails. If the truck be held by elastic springs before and behind (comparable to the tension between the condenser terminals) it acquires an inertia of swing under the influence of properly timed pushes, and with small expenditure of power may gradually become the centre of enormous energy. The condenser in the transmitting circuit tends to reinforce and also to steady the vibrations of the dynamo current.



LODGE'S SYNTONIC RECEIVER AND TAPPER.
(From *The Electrician*.)

SURPRISING EXPERIENCES.

With this apparatus Sir Oliver Lodge had some surprising experiences. He could not only intercept, but effectually deranged all the telephone messages in the neighbourhood of Liverpool, and his working was occasionally perceived a hundred miles away. This, of course, was a disadvantage in a busy industrial centre, and means had to be taken to render the system innocuous. What these means are have not been disclosed, but it is understood that Sir Oliver Lodge and Dr. Muirhead have been perfecting the system, the essentials of which were patented in 1897, and that magnetic induction may yet come forward as a rival to spark telegraphy in the competition for long distance communications.

(*To be continued.*)

SIR ANDREW NOBLE AND ELSWICK.

A Biographical Sketch.

IN the early autumn of 1860 Lord Armstrong took one of the most judicious steps of his career, and invited Captain Noble, a young officer already recognised as an expert in artillery matters, to join his newly-formed ordnance works at Elswick. Forty years have elapsed since that offer was made, and, in a fortunate hour for Elswick, accepted. To-day, Captain Noble has become Sir Andrew Noble, and is the chairman of Sir W. G. Armstrong, Whitworth and Co., Ltd. All the later extensions and developments of the business have been carried out under his direction, and time has done nothing to diminish his energy and activity, both in the interests of the firm and in the advancement of the science to which he has devoted himself.

Sir Andrew Noble was born at Greenock in 1832. His father was a naval officer, the scion of a Dumbartonshire family, whose estate, lost for a generation, was repurchased in 1889 by the subject of this sketch. Having completed a course at the Edinburgh Academy, Sir Andrew passed through Woolwich and received in 1849 a commission in the Artillery, afterwards serving with his regiment in Malta, Canada, and South Africa. He was especially attracted by mathematical studies and scientific research. In 1858, upon his return from the Cape of Good Hope, he acted as secretary to the Royal Artillery Institution, and the same year was appointed Secretary to a Special Commission upon Rifled Cannon. His increasing reputation as an expert caused him to be nominated by the War Office to various positions in connection with the subject of guns and their ballistics, and he was Assistant Inspector of Artillery when, as we have mentioned, Lord Armstrong invited him to join the Elswick Works.

It may not be uninteresting at this point to recall the main facts connected with the history of the firm. It was as long ago as 1847 that Mr. William Armstrong opened a modest factory at Elswick, in which to manufacture his hydraulic cranes. He was at the time a partner in a solicitor's business in Newcastle, but his leisure hours had been devoted to mechanical and electrical experiments, and he was already known as an inventor of boldness and originality. Assisted by four of his fellow townsmen, who joined in subscribing the £20,000 of capital required, he bought a couple of meadows on the banks of the Tyne, and started his hydraulic engineering works. Shortly after the opening, the Armstrong cranes had the good fortune to attract the notice of the engineer of the Liverpool docks, Mr. Hartley, and were adopted by him. Increased custom followed, and the business was in a prosperous state when, some eight years after its inception, the attention of its founder was directed to a new sphere of invention. The outcome of this new departure was the Armstrong gun, which, brought to the notice of the authorities during the Crimean War, gained for itself, after many competitive trials, the favour of the Government and was accepted as the service weapon. In later life, Lord Armstrong used to protest that he only took up the study of artillery as a hobby, suggested by the martial ardour of the moment, and that he had hardly any notion of turning his ideas to practical effect. But he attacked the subject with characteristic energy and concentration, and the result was an increased reputation for himself, and an altered destiny for his works at Elswick.

Under arrangements which were too complicated to prove satisfactory, Mr. Armstrong entered the service of the Government in order to superintend the making of his new guns at Woolwich. At the same time, to assist in meeting the demand, artillery works were started at Elswick, where, it must be remembered, there was already a staff of skilled operatives with experience in this manufacture. Though these shops were side by side with the existing engineering works, the two concerns were kept separate. The hydraulic business continued as before, and the Elswick Works commenced as a Government arsenal, bound by agreement to make guns for no other Power but England. The utmost secrecy was preserved, and the intrusion of foreign observers was rigorously prevented. Lord Armstrong, to give him his title of later life, possessed in a marked degree one characteristic of the successful leader. He chose his subordinates with foresight, and seldom made mistakes in his estimate of ability. We have already referred to Sir Andrew Noble in this connection, but in the early years of his engineering enterprise, Lord Armstrong owed much to the capable assistance of Mr. Percy Westmacott, and when the ordnance works were started, he appointed a manager of great ability in Mr. George Rendel. Both these gentlemen are still directors of the company which owes so much to their efforts, but both have long since retired from active management.

In 1860 the shops at Elswick were crowded with Government orders, and the fortunes of the place seemed tolerably assured. Within the short space of three years the conditions were entirely altered. The contracts ceased, the ardour of the Government cooled, and the authorities paid the Company a sum of money to close the arrangements which had been made. Lord Armstrong resigned his Woolwich appointment and returned to Elswick, where the workshops, equipped with costly machinery, stood almost empty. The engineering works and the ordnance works were united into one concern, and the partners commenced to establish

THE JAPANESE WARSHIP "YASHIMA" PASSING THROUGH THE HIGH LEVEL BRIDGE AT NEWCASTLE.

a foreign connection. The War Office has been the hero of many singular proceedings, but one of the most mysterious episodes in its history was its complete neglect for nearly fifteen years of the technical resources which were ready to hand at Elswick.

During this period of official stagnation, the science of artillery was making rapid progress under Lord Armstrong, Mr. George Rendel, and Sir Andrew Noble. Yet it was not until the Russian war scare of 1878 that the Government purchased four 110-ton guns, built for the Italians, and passed them into our own service. Nor was it until more than twenty years had gone by since the desertion of 1863, that the Elswick experts finally succeeded in forcing upon the attention of our own authorities the new type of gun, which is now everywhere adopted.

Particulars of the advance in gun designing and construction are no doubt familiar to many, but may be briefly recapitulated. The original Armstrong six-pounder gun was made of coiled wrought iron cylinders, shrunk upon an inner barrel, which was at first of steel. It was a breech-loader, with a breech-block screwed in, and was rifled upon the polygroove system, with a uniform twist. Subsequently, certain steps, which appear to us retrograde, but which were doubtless necessitated by the conditions of the period, were taken. Steel was given up on account of its unreliable nature, and a return was made to muzzle loading. The Armstrong system of construction, however, opened the way for an exceedingly rapid increase in the size of guns, so that in 1875 we had guns of 100 tons weight.

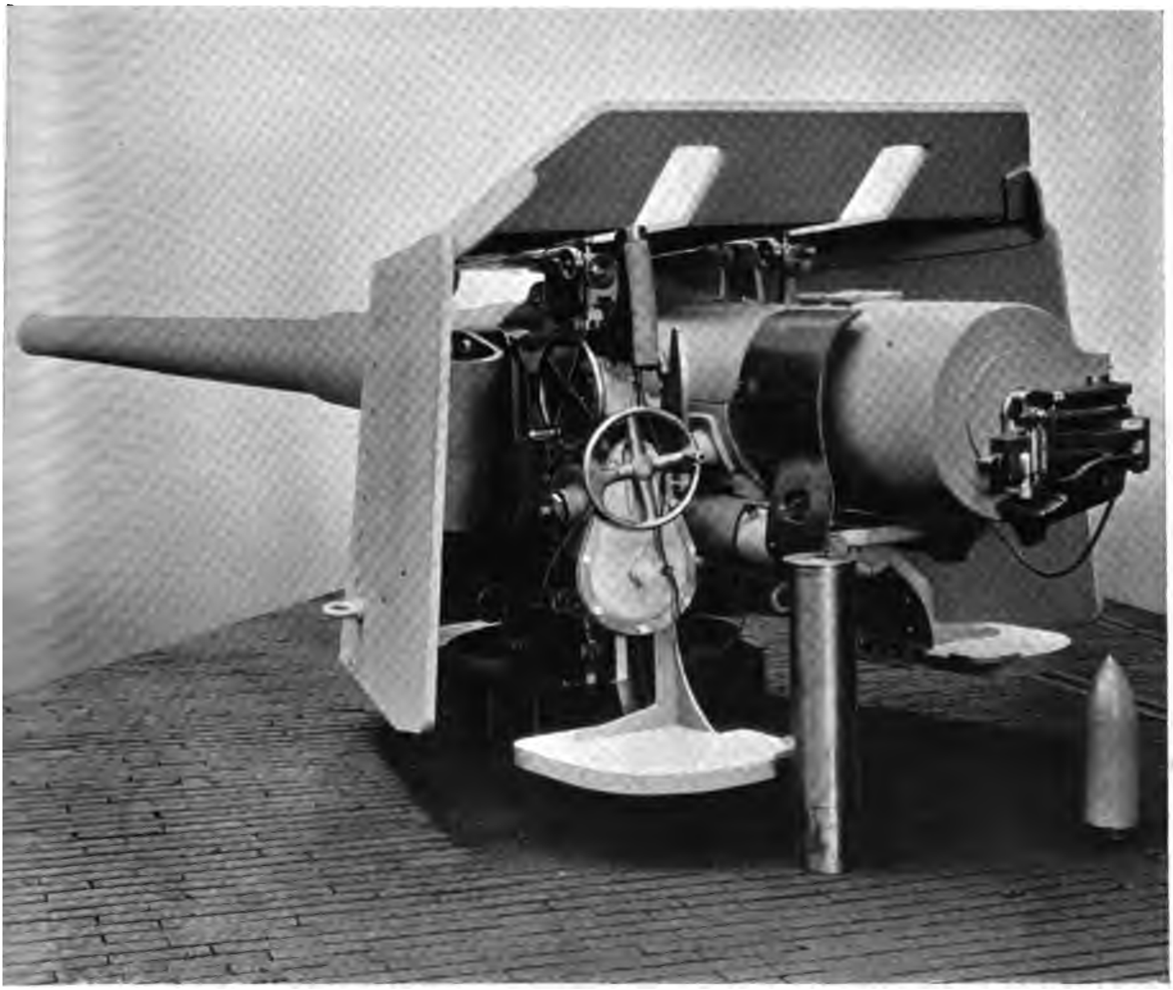
Meanwhile, Sir Andrew Noble was bringing to bear upon the subject an amount of accurate research hitherto unknown. He began by experimenting with closed cylinders in which charges of powder were fired by electricity, pressures were recorded, heat determined, gases analysed, and the products of explosion examined. He also invented the chronoscope, which bears his name, for ascertaining the velocity of a projectile in the bore of a gun. This was quite novel work, and was soon to take a practical shape. The old gunpowder was changed, and a powder, burning regularly and slowly, took its place; steel, the manufacture

LATEST PATTERN 4·7 IN. QUICK-FIRING GUN.

of which had been greatly improved, was re-employed as the proper material, and gradually the new type of gun was evolved. These facts are, of course, the common-places of history, though, in the glare of latter day advertisement, the pioneers are apt to be sometimes obscured.

We reproduce photographs of the latest patterns of 12-pounder, 4·7 in. and 6 in. quick-firing guns. In addition to the increased length of the bore, features common to quick-firing guns will be noticed in the photograph—the breech mechanism with its interrupted screw and single-motion action, the hydraulic recoil presses, and the absence of trunnions on the gun, which recoils in a cradle.

The first gun known as Quick-firing was the 4·7 in. gun made in 1886. It was employed for the armament of the Italian cruiser *Piedmonte*, built at Elswick in 1889. The 4·7 in. gun shown in the photograph is mounted on a travelling carriage for field service, and the following are its dimensions and ballistics. Total length, 194·1 in.; weight, 42 cwt.; charge, 5 lbs. 7 ozs.; projectile, 45 lbs.; muzzle velocity, 2,188 foot seconds; energy, 1,494 foot tons. It can fire ten rounds per minute.



LATEST NAVAL 6 IN. QUICK-FIRING GUN.

The naval 6 in. quick-firing gun illustrated is

249·25 in. long, and weighs 6 tons 12 cwt. The charge is 15 lbs., and the projectile 100 lbs. The muzzle velocity is 2,300 foot seconds, and the energy 3,668 foot tons. Six-inch guns are constructed up to 50 calibres, or 300 in. in length, and with the increased length of bore, velocities up to 3,000 ft. are obtained.

The 12-pounder quick-firing gun is interesting as being a gun from the battery presented by Lady Meux to Lord Roberts in 1900, and used by the Elswick Battery in the South African campaign. The total length is 123·6 in., and the weight 12 cwt. The charge is 1 lb. 15 ozs. and the projectile 12 lbs. 15 ozs. The muzzle velocity is 2,210 foot seconds, and the energy 423 foot tons.

Turning now to some of the other developments of Elswick, we revert to 1869, when Mr. George Rendel designed the gunboat *Staunch*, and the attention of the company was directed to the building of warships. These were first constructed according to Mr. Rendel's designs in the shipyard of Mr. Charles Mitchell, at Walker-on-Tyne, and when in 1882 the firm became a limited company, Mr. Mitchell's yard became part of the business, which was entitled Sir W. G. Armstrong, Mitchell and Co., Ltd. In 1884 a second shipyard, exclusively for war vessels, was opened at Elswick, under Mr. White, who, as Sir William White, afterwards filled the position of Naval Constructor at the Admiralty. Mr. White, upon being appointed to the Admiralty, was succeeded by Mr. Philip Watts at Elswick, on October 1st, 1885.

The cruisers and battleships from Elswick, of high speed and heavily armed, have strengthened many navies, and are inseparably associated with the genius of Mr. Watts. The photographs given with this article show the passage of the Japanese battleship *Yashima* through the High Level Bridge at Newcastle, in June, 1896, the launch of H.M.S. *Lancaster*, and the Chilian 30-knot torpedo-boat destroyer *Capitan Thompson*.

Space prevents the insertion of full particulars of these ships, and prevents also the enumeration of many other well-known

12-POUNDER QUICK-FIRING GUN.

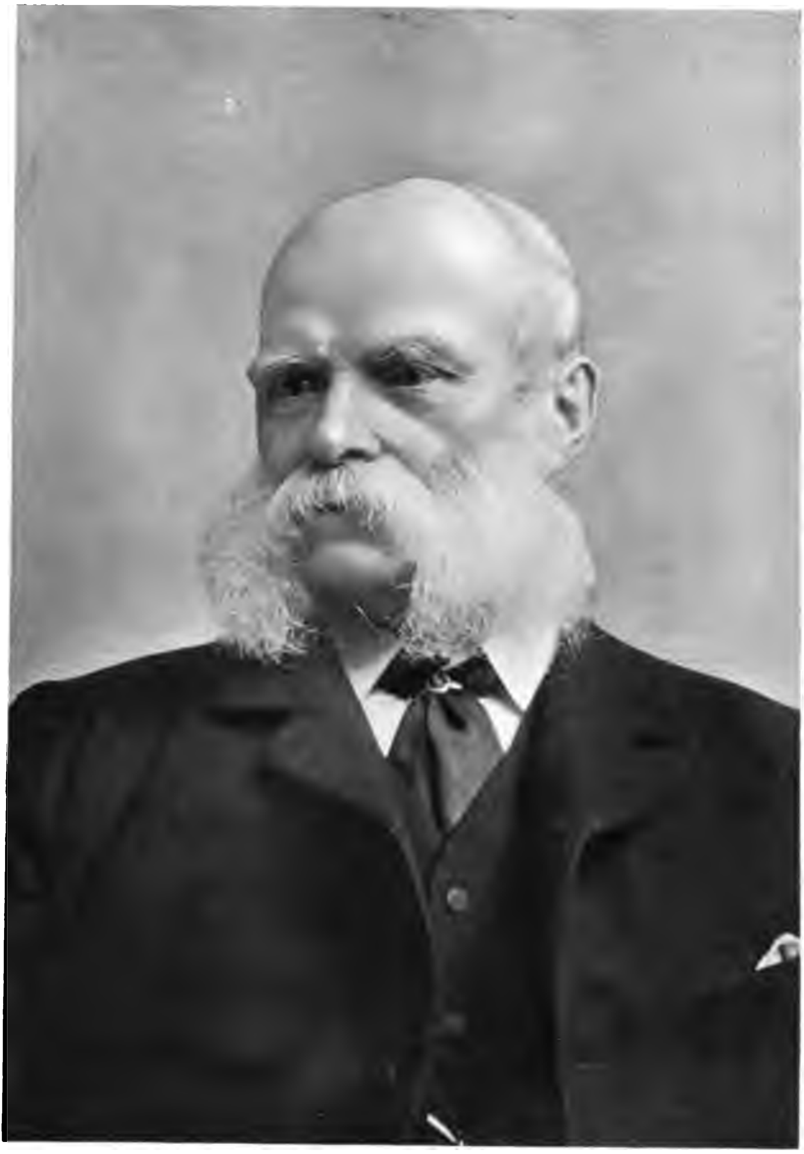


Photo by Elliott and Fry.]

SIR ANDREW NOBLE, BART., K.C.B., F.R.S.

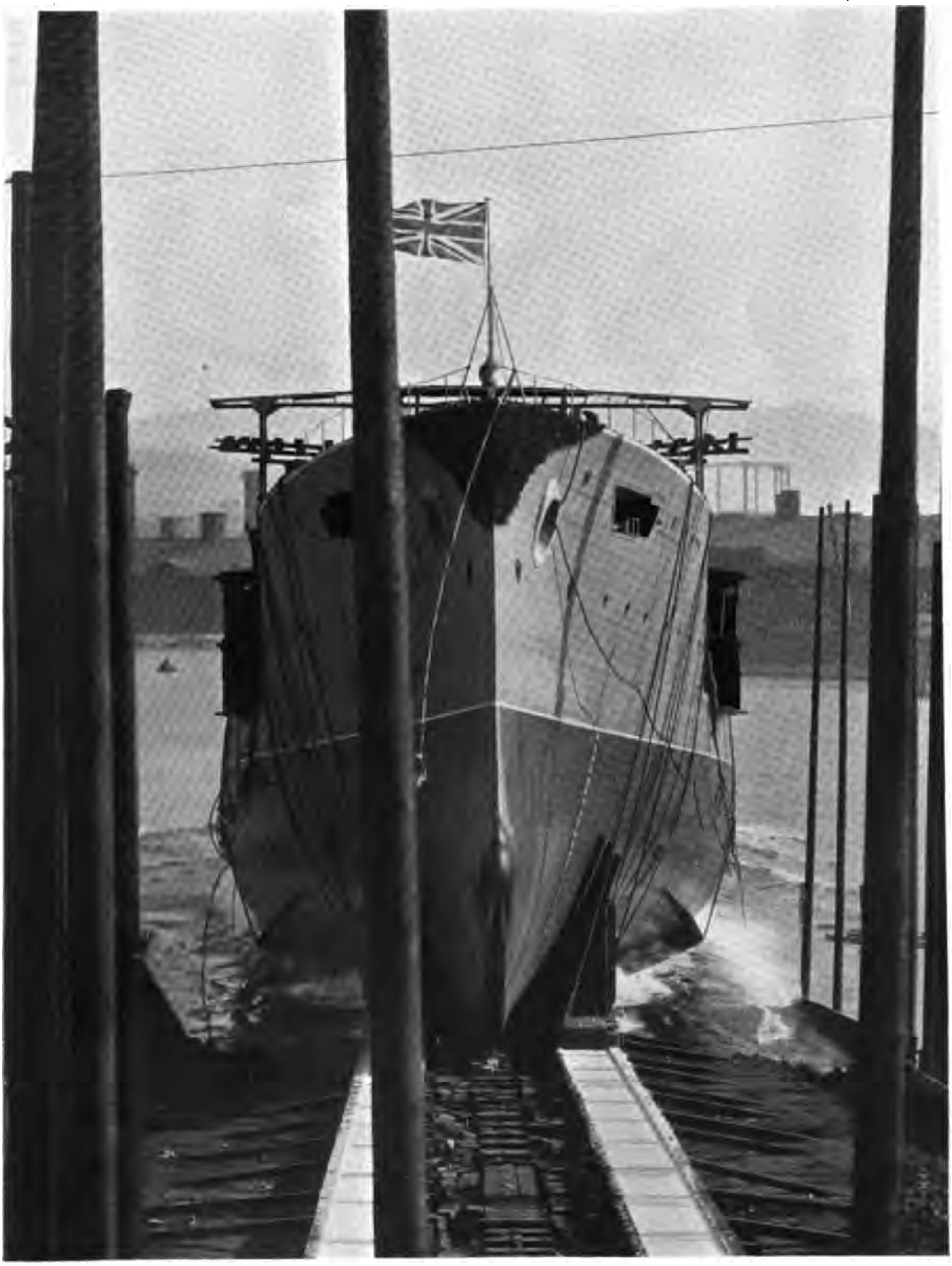
armour-clads and cruisers which have issued from the same yard. Mr. Watts left Elswick in 1902 to succeed Sir William White as Director of Naval Construction at the Admiralty, the highest position that a Naval architect can obtain.

As the Elswick Yard is devoted to warships, the Walker Shipyard of the company confines itself chiefly to the construction of merchant vessels. Among the most interesting of these is the ice-breaker *Ermack*, whose services to Russian commerce in frozen seas have been widely portrayed in journals and magazines. A speciality has also been made of tank steamers for carrying petroleum in bulk, under the patent of Mr. Henry Swan, the present head of the yard. The patronage for many years of the Italian Government led to the establishment of a branch arsenal at Pozzuoli, on the Bay of Naples. This arsenal is used for Italian work, and employs more than a thousand hands. Another undertaking, almost inevitable for a business where so many heavy steel castings and forgings are needed, was the starting of the Elswick Steel Works, under the late Colonel Dyer, in 1882.

The most important step resulting from the forward policy of the Company was, however, the amalgamation with Sir Joseph Whitworth and Co., in January, 1897, combining under one title the names of two engineers, each great in his own line, and at one period vigorous rivals—the late Lord Armstrong and the late Sir Joseph Whitworth. The Openshaw Works may be said to have the advantage in point of seniority over Elswick. Mr. Whitworth, it may be remembered, after working at Maudslay's, Holtzapffel's, and Clement's, returned to Manchester in 1833, and put up a sign—"Joseph Whitworth, Tool Maker, from London." From this workshop has grown up the large manufacturing establishment at Openshaw, where are steel works, gun works, and shops for making machines. Finally, a plant for making armour plates for ships has been started here within the last year or two.

The Armstrong, Whitworth Company can turn out a battleship fully armed and armoured,

CHILIAN 30-KNOT TORPEDO-BOAT DESTROYER "CAPITAN THOMPSON." BUILT AT ELSWICK.



LAUNCH OF H.M.S. "LANCASTER."

though not engined, as they have not yet taken up marine engineering. Among their other productions, in addition to guns, mountings, and projectiles, are merchant vessels, steel of all kinds, machinery, electrical and hydraulic machinery. The Company's shops cover 224 acres of ground; it employs about 25,000 men and pays £30,000 a week in wages.

SIR ANDREW NOBLE IN HIS LABORATORY.

In the course of his long career and association with the works, Sir Andrew Noble has naturally received numerous honours. He was created a C.B. in 1881, and K.C.B. in 1893, and a Baronet of the United Kingdom in 1902. In 1870 he was elected a Fellow of the Royal Society; and in 1880 received the Royal Medal of that Society. He is a Knight of various foreign orders, and has been honoured by many learned and scientific bodies. For the past two years he has served with Lord Rayleigh and Mr. Haldane, M.P., upon the Explosives Committee.

Probably few men have wider sympathies, or a more catholic taste, than Sir Andrew Noble. His popularity among those who work under him at Elswick is immense; his circle of friends is wide, and he is never happier than when surrounded by them in his beautiful place at Chillingham.

In his youth an athlete of distinction, there is hardly a form of sport or game which he does not patronise and support with enthusiasm, and, when necessary, with generosity. He owns one of the few private tennis-courts in England, and many thousands of acres of partridge and pheasant shooting, both in Northumberland and Norfolk. He is a fine shot, but was debarred by an accident from indulging in this form of sport last season.

Sir Andrew is a man of wide reading and culture, versed not only in scientific, but also in general literature. Of the two accompanying photos, one is by Messrs. Elliott and Fry. The other is furnished by an accomplished amateur, who had the privilege of taking Sir Andrew while at work in his chemical laboratory.

IRON AND STEEL MANUFACTURE.

TRANSPORTATION OF MINERAL FROM FURNACE STOCKYARD TO MOUTH OF FURNACE.

BY

B. H. THWAITE, C.E.

The Author in the two preceding Articles dealt with the choice of a site, the selection of ores, and the most economic methods of transportation.—Ed.

III.

STOCKING THE MINERALS.

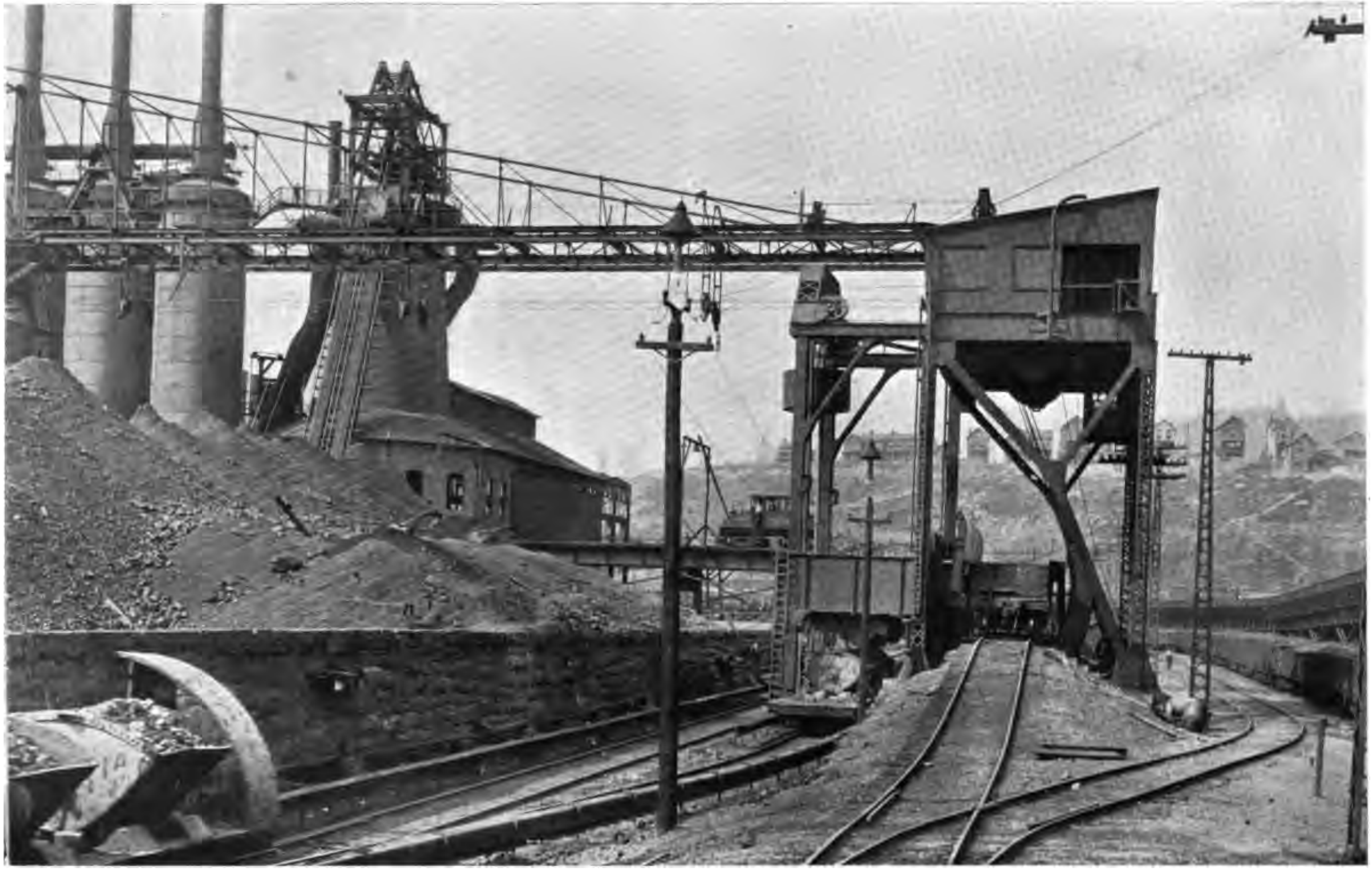
THE system adopted, by which the car is cleared of its contents, is a development of the tipping method in use in many of our coal-shipping ports, with this important difference, that in the American system not only is the car discharged by being overturned, but the operation is effected in such a way that the mineral is actually deposited at a higher level.

On referring to the illustration on page 276, it will be seen that part of the railway track, or siding, is detachable, so that it can be bodily lifted with its car load. The detachable track is mounted on a cradle-like structure, U-shaped, as heavily constructed as would be an ordinary plate girder bridge, because the dynamic programme involves not only the overturning of the car and its contents, but also its bodily lifting. It will be noticed, on referring to the figure, that the cradle track is mounted on a heavy shaft of 10 in. diameter, around which it is bodily turned or rotated through a section of a circle.

The motion of the tilting cradle is effected by means of steel wire cables that pass under the framework of the cradle structure, and around the drum of an electric winding engine located in an engine-house, directly and substantially superposed over the track tilting cradle.

A counterbalance weight is provided in order to assist in overcoming torque and inertia effects. The counterbalance weight not only comes into action for the purposes described, but it serves as a brake when the track cradle has passed into the zone of gravity influence, and in such a way that the weight of the car in falling by its own gravity is taken up by the counterbalance weight, which is consequently lifted or hoisted, and in its suspension constitutes a rapidly effective source of reserve energy to assist the electric motors in lifting the track cradle and its ore contents. Before the track cradle is put into motion it is rigidly held by a simple hydraulic clamp, adjustable for use with mineral cars of the largest capacity and under.

The ore or mineral contents of the car, when tilted, fall on to an inclined steel plate, by which they are diverted or deflected into a steel bin of ample capacity for receiving the contents of two of the maximum capacity cars.



HIGH CAPACITY MINERAL TILTING CRADLE AND ORE BINS.

Showing a portion of the Brown Hoisting Crane, Stockyard, and Electric Bucket Car Siding; also illustrating the Furnace and two Stoves.

The high structural efficiency of the large capacity 40 to 50-ton cars makes this system of discharging most effective and rapid; for instance, one ordinary tilting apparatus will discharge a 50-ton car in two minutes. This is equivalent to an hourly capacity of car discharge—including the lifting of the ore—of 1,500 tons, and the reception bin capacity should be of equivalent proportions, because it is quite obvious that the bin discharge must be as rapidly effective as the operation of charging. The bins can, of course, have twin discharge doors, one on each side, the floors of the bins inclining towards each discharge door.

The bins are longitudinally divided into two compartments of a size proportionate to the capacity of two electrically propelled cars, that travel directly under the bins and their discharge doors. Each car carries two specially constructed buckets. To differentiate these cars and their buckets, they will be referred to in this article as bucket cars. The bucket cars are the agents by which the mineral is transferred to the stock heap.

The bins are divided into compartments, so that the discharge can be proportioned to the capacity of the buckets provided for receiving the mineral. The bin discharge doors have independent actuating gearing, electrically driven, and any one of the discharge doors can be put in motion from one point. Each of the compartments has a storage capacity of some ten tons.

The bucket cars—heavily constructed—are independently electrified, collecting their energising current from side conductors, consisting of guarded iron bars, on which slide the contacts as shown in the figure. The bucket car sidings are so arranged that the discharged bucket cars can be shunted out of interference with the movement of the full cars—the switches being self-operating, either by the assistance of rising grooves or by springs—so that the cars, in their movement past the location of discharge, are automatically diverted on to a siding that brings them round to the bins, the operations thus being continuously cyclical. Two bucket cars are generally coupled together. One of them is provided with a steel guard or cover under which a man controls the movement of the bucket cars.

Each car has places for two buckets, position or seating blocks being provided for maintaining the buckets in position. Only three full buckets are actually carried by the two cars. The fourth bucket location is provided to permit the bucket car, after discharge, to be returned to the bins with the least possible loss of time. The vacant location receives the empty bucket left by the preceding cars, because the bucket cars return to the ore bins when the last bucket has been lifted from it by the overhead traveller crane. A sectional view of the bucket is shown in fig. 1.

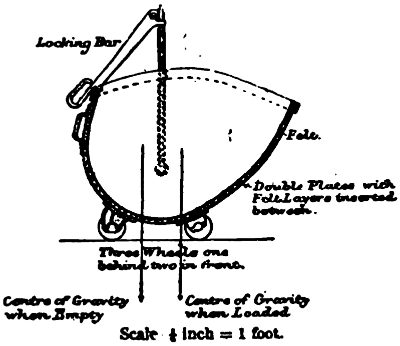

Locking Bar
Felt.
Double Plates with Felt Layers inserted between.
Three Wheels one behind two in front.
Centre of Gravity when Empty
Centre of Gravity when Loaded
Scale ¼ inch = 1 foot.

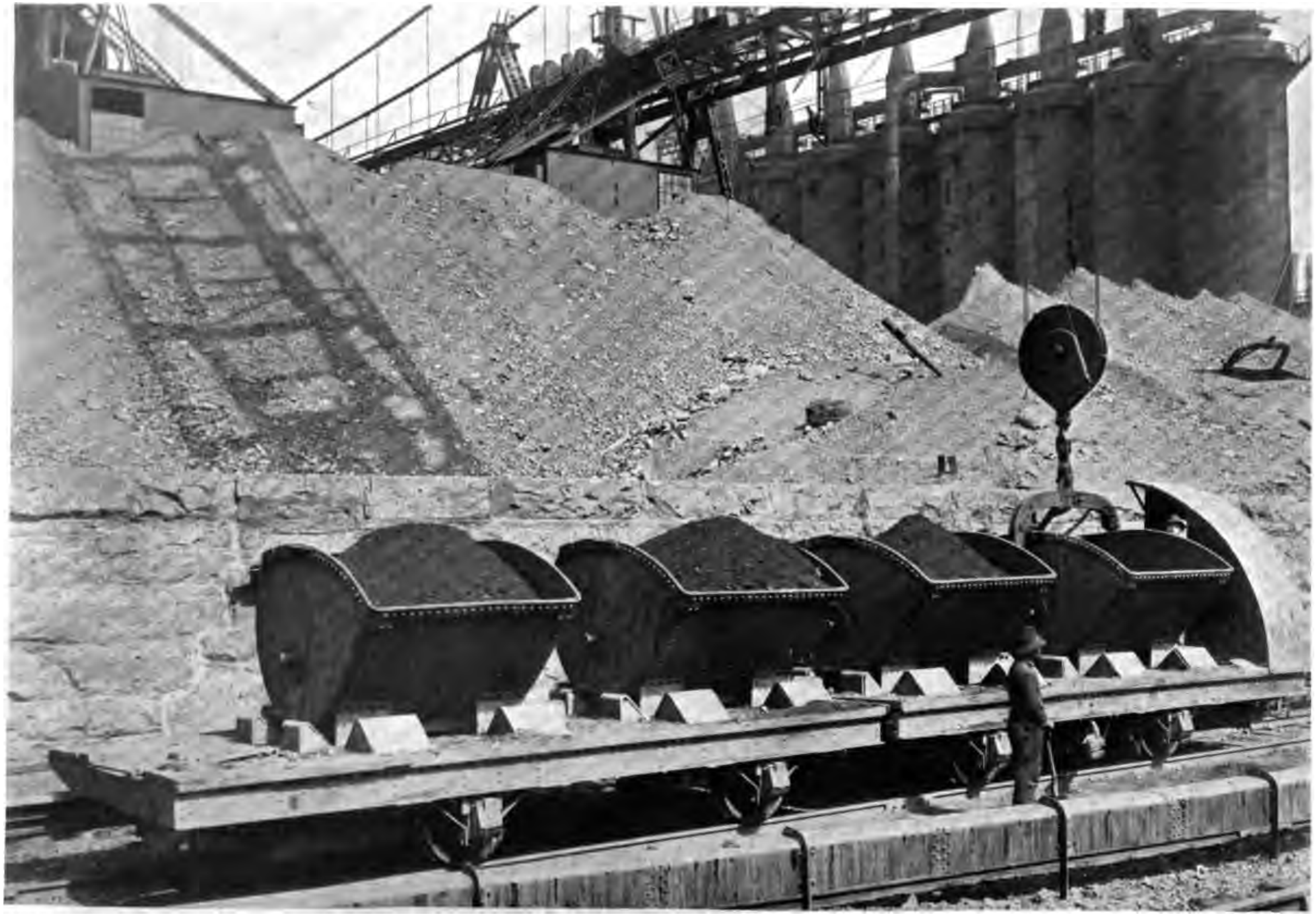
FIG I. SECTION OF ORE BUCKET.

FROM CAR TO STOCK PILE.

The hoisting, distributing and discharge of the bucket contents are effected by means of a Brown traveller or transporting crane, which we owe to the ingenuity of the engineers of the Brown Hoisting Company. For the distribution and stacking of minerals this type of crane possesses many advantages—especially where speed and enormous capacity are the most desirable requirements.

Of course, such a type of crane is only available for outdoor service, and when the principle of removing the ore outside the serious influences of wet weather has to be considered, this type of crane will of necessity have to give way to the ordinary traveller or other equivalent.

The central span of the Brown Hoisting Crane is 250 ft. long. One end is supported by a vertical built-up standard, the opposite end being supported by a sheer leg. The main horizontal girder is 62 ft. above the stock floor level. One girder cantilever, 160 ft. long, projects over the portion of the stockyard and over the



ELECTRIC BUCKET CARS FOR TRANSFERRING MINERALS IN THE STOCKYARD.

Showing Crane Attachment to one of the Buckets.

receiving portion of the bucket car siding. At the opposite end the girder projects 148 ft. The central girder part and the two projecting girders at each end make up an overall crane length of 550 ft., providing a sweep for hoisting and traversing effort equal to 540 ft. The traversing distance is of course only limited by the length of the pier tracks.

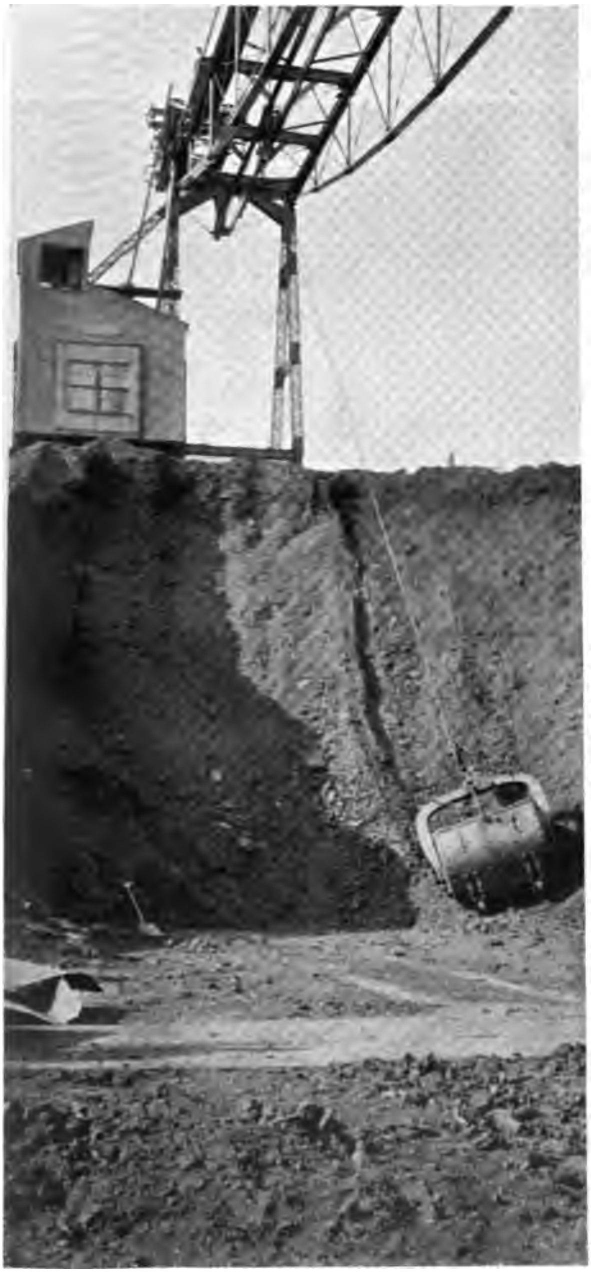


FIG. 2. SHOWS OPERATION OF FILLING ORE BUCKET.

The Brown Crane has its own engine-house equipment, located in such a position as will permit the greatest possible transverse movement of the buckets. The construction of the standards is clearly shown in the illustrations. The standards at their base have a width of 19 ft. 6 in., being reduced to 15 ft. at the top. The rail carriage supporting the standards is most strongly and solidly constructed. The sheer leg part of the crane is formed of two steel posts, separated at their base by some 20 ft., but joined above the stringer level of the crane. The two posts are strongly braced together, and rest solidly on their carriage, the latter being formed of two trucks as shown.

The Brown Crane is operated electrically, the potential of electrical power being made up of two 135 h.p. electric-motors installed in the crane engine house. The motions of propulsion, hoisting, and haulage are transmitted to the truck wheels of the carriage, carrying the crane supports, by means of suitable shafting and gearing. Suitable contrivances prevent the shafting from being subjected to excessive or abnormal torsional influences such as would be caused through changes in the position of the crane supports. For instance, the crane is centralised on the main standard support, and it can be made to turn through the distance necessary to prevent the disturbance or strain of the motion transmitting shafting.

The general construction of the crane is based on an inversed application of the bow-string principle of bridge construction, the bottom cords being parabolic and the upper ones straight. All the compression members are built up of mild steel channels, gas tubing being employed for the tensional members. In order to obtain the necessary metallic cross-sectional area for the main tensional members, with the minimum degree of wind-resistance area, these members are, wherever possible, made of plate steel with only their edges exposed to horizontal wind pressure effects. The subordinate tensional members, such as the diagonal ones, are made of the best wrought iron.

Hanging beams, extending the entire length of the crane, carry the traversing bogie or trolley throughout its entire course from end to

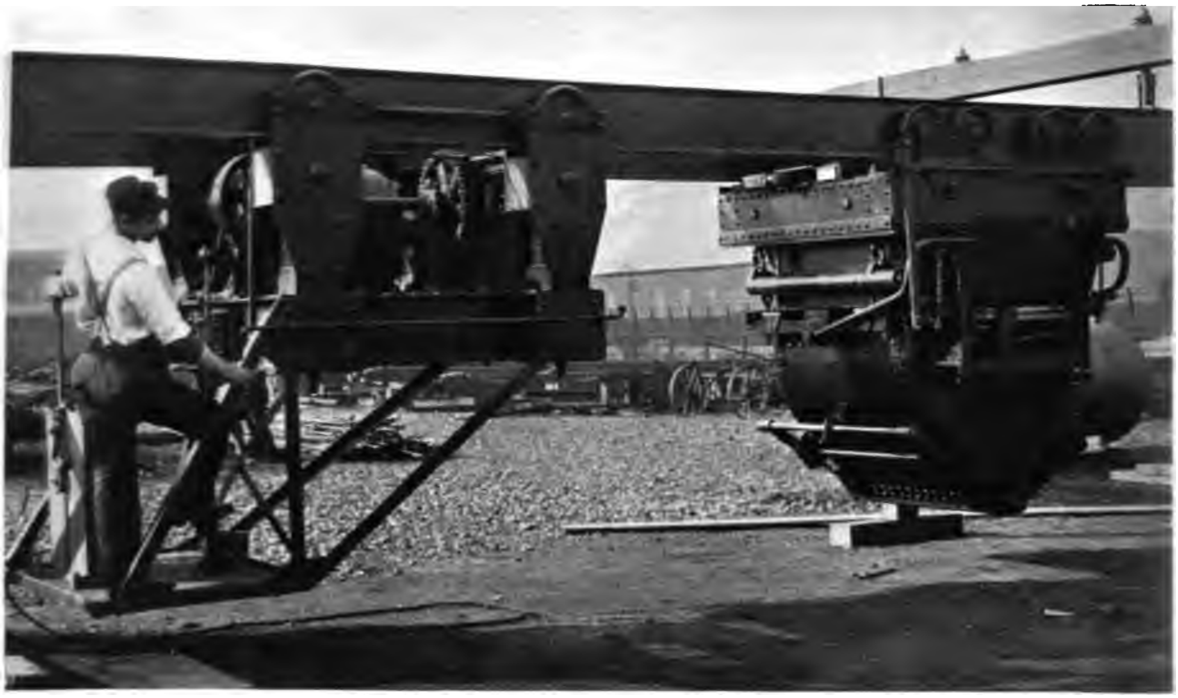


FIG. 3. STOCKYARD ELECTRIC-LOCO., WITH ITS MINERAL CAR SUSPENDED (WEIGHING TYPE) FOR TRANSFERRING THE ORE FROM THE STOCKYARD TO FURNACE ELEVATOR.

end, or 540 ft., the standards being so formed as to permit the unobstructed movement of the trolley and its suspended bucket. The trolley is hauled backwards and forwards by means of a steel rope, actuated by a winding engine located in the engine house.

The rapidity and effectiveness of the crane is such that a bucket of mineral, of a holding capacity of 9 to 10 tons, and having a tare weight of 13 tons, can be transferred from one point to another at a speed of 12 to 15 ft. per second, and lifted bodily at a speed of 4 to 5 ft. per second. The crane is easily capable of hoisting, transmitting and discharging thirty bucket loads, or 300 tons of minerals per hour.*

The object of the pointed spears projecting from the sides of the crane buckets is to reduce the amount of side scattering of the minerals when the bucket is overturned. By means of a simple trapeze gear, controlled from the crane engine house, it is possible to tip over or discharge the bucket at any point desired.

Of course, the ore can be transferred direct from the railway sidings to the well of the furnace hoist. It is usual, however, to provide an ample margin of stock, to satisfy all normal contingencies, as the working of a large capacity furnace from mine to furnace mouth without such margin is dangerous.

FROM STOCK HEAP TO FURNACE ELEVATOR.

We must now consider the arrangement for transferring the mineral on the stock heaps to the furnace elevator.

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* AERIAL AND LINK CHAIN TRANSPORT METHODS.—The author has noticed that in Germany aerial methods of transporting minerals are in regular use—in some instances the transmission distance is very considerable.

The actuation of the trolley can be effected either by mere steel rope haulage or by electricity. The system so far does not appear to have been applied for distributing the minerals longitudinally and transversely, but the author is satisfied that within a certain range of area at least both directions could be covered simultaneously.

The evolution of transportation by link chain methods has greatly progressed within the last few years, and no scheme of mineral transportation should fail to take the merits of this method into account, especially when the agitation of the material in motion is not likely to produce physical disintegration. The link chain system, however, in any of its applications is likely to have a higher power absorption for a given weight transmitted than the aerial or Brown crane system.

Another type of transportation apparatus and one entirely of British origin is the Temperley transporter. This possesses many of the advantages of the Brown hoisting arrangement and has already been applied for mineral transportation purposes.

The bucket used for this purpose is peculiarly designed. It is really a neat combination of a shovel and a container. The *modus operandi* is as follows: the bucket, with its shovel mouth, is dragged over the sloping or inclined surface of the mineral pile and in its movement it is rapidly filled. (See fig. 2.) The entire operation is controlled from the engine-house. Automatic indicators show the operator when he may hoist, traverse, or overturn the bucket and apply suitable brake clutches.

The bins for receiving the minerals, etc. (inverted truncated cones in cross section), have double discharge doors—one delivering the mineral to the right and one to the left. The bin discharge doors are curved to a radius of a circle, and they revolve around a horizontal axis, although each door can be independently actuated. The bins discharge their contents into a suspended electric hauled car. (See fig. 3.) Each car has its own independent electric-loco., powerful enough to haul two cars—which are suspended from bogies running on girders, fixed and arranged in such a way that the discharge of the minerals is not intercepted. The car is equipped with weighing scales, so that the electric-loco. driver can charge his car with a predetermined mixture, made up from different bins.

This suspended electric - loco. stockyard mineral car train delivers the charge to the furnace elevator well, or at a location near to the furnace hoist. The same suspended and electric-loco. car, adapted to the coke bins, permits the coke to be hauled rapidly to the furnace elevator well, where it can be mixed with the materials making up the furnace burden.

DUQUESNE INSTALLATION.

The stockyard of the famous Duquesne Plant has ample space for the storage of 600,000 tons of ore. Its dimensions are: length, 1,085 ft.; width, 226 ft.

The stockyard is spanned by three Brown travelling cranes of the character described. During stocking season, Hopper bottom cars are discharged into bins arranged in two rows, one of which is allocated to supply the immediate demands of the furnaces; the other row, nearest stock accumulation, is used for transferring ore from the cars to the ore buckets. The latter, when filled, are picked up by the crane and automatically dumped on to the stock piles.

The removal of the ore from the stock piles is accomplished by the drag or bucket crane, as described. The holding capacity of the drag bucket is five tons. The drag buckets collect the ore from the face of the heap or pile, and then transport it either into the bins or bin-filling cars. The loaded cars are run over the bins allocated to receive their contents.

LORAIN COMPANY'S INSTALLATION.

In the Lorain Company's installation the stock bins are located underground. The stock bins are 725 ft. in length. The stock bin cars, electrically propelled with their own motor, are equipped with self-contained weighing hoppers, so that the carman can both transport and weigh. Five of these transport and weighing cars satisfy the requirements of two furnaces. The discharge door of the transport hopper is opened and closed by a direct and vertically operating pneumatic cylinder, the air being compressed by an electric-motor. The ore, limestone, and coke are transported, weighed, and delivered to the furnace skip car by the transport and weighing cars that draw their supply from the chutes in the bottom of the bins. The skip car then conveys the charges up the incline and delivers them at the furnace top.

FROM FLOOR TO PLATFORM OF FURNACE.

In the modern American practice the vertical lift elevator, whether direct lift winding, hydraulic or steam, has been displaced by the inclined rail track similar to that shown in fig. 4, or that of the illustration on page 282, showing the general elevation of a mineral elevating equipment and associated charging gear of a modern American furnace. By a very clever device the skip is made automatic or self-discharging, its contents passing direct into the well of the charging bell.*

It will be noticed on referring to the figures that the gauges of the front and back wheels of the charging skip are different, the rear wheels

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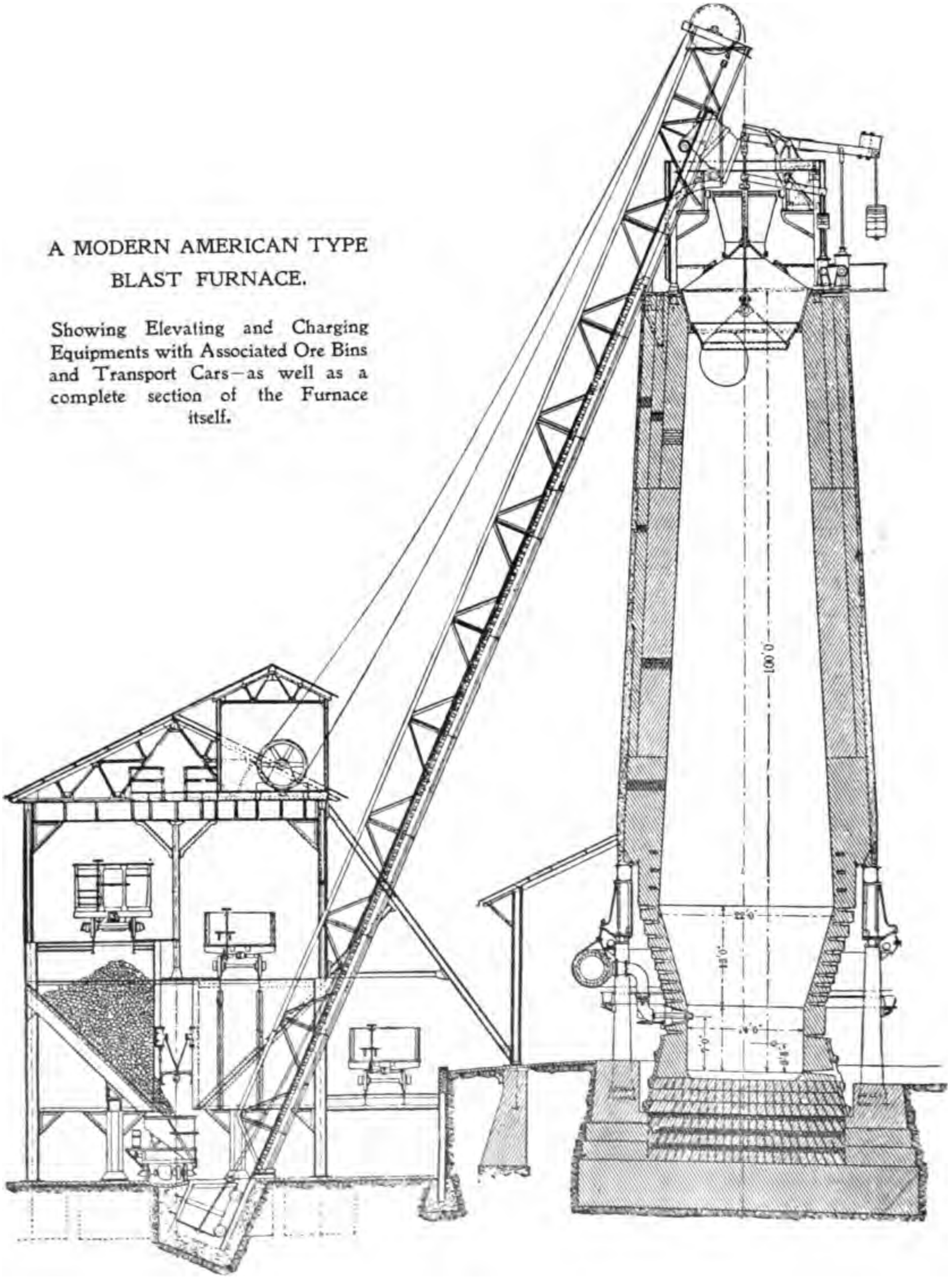
* The usual angle of the skip on tilting discharge is 67 deg. from the horizontal plane.

The skips are hoisted by a pair of 1¼ in. steel cables—the winding drum has a diameter of 6 ft., and may be operated by steam or electrically.

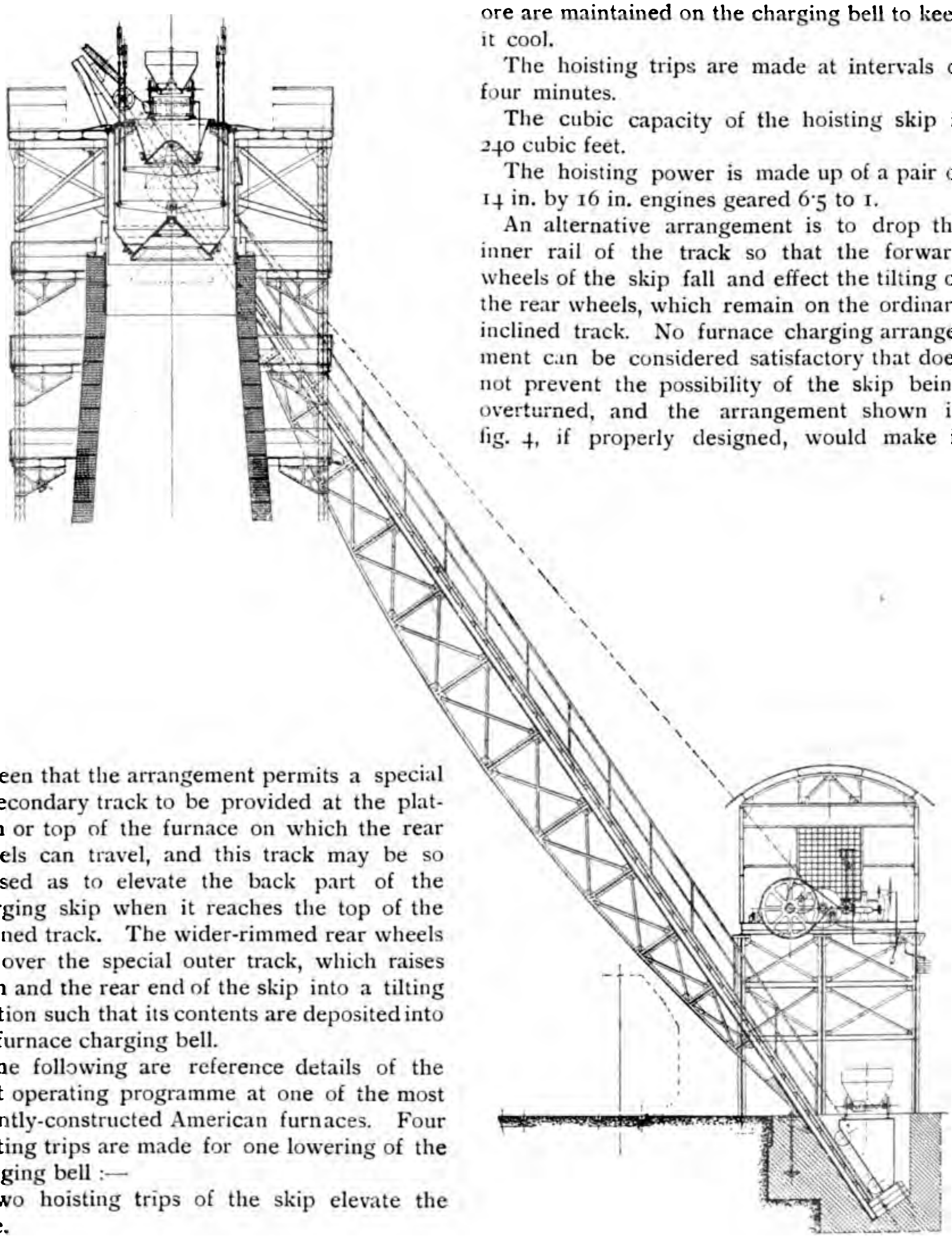
In order to lessen the impact effect, when the skip reaches the tilting height, a spring buffer is provided for the rear wheels of the skip.

A MODERN AMERICAN TYPE BLAST FURNACE.

Showing Elevating and Charging Equipments with Associated Ore Bins and Transport Cars—as well as a complete section of the Furnace itself.



having a wider rim surface than the front ones. The object of this dissimilar wheel rim width will be obvious. On referring to fig. 4, it will be seen that the arrangement permits a special or secondary track to be provided at the platform or top of the furnace on which the rear wheels can travel, and this track may be so devised as to elevate the back part of the charging skip when it reaches the top of the inclined track. The wider-rimmed rear wheels run over the special outer track, which raises them and the rear end of the skip into a tilting position such that its contents are deposited into the furnace charging bell.



ELEVATION OF INCLINED FURNACE HOIST (GERMAN-AMERICAN TYPE) WITH DOUBLE BELL CHARGING GEAR.

The following are reference details of the hoist operating programme at one of the most recently-constructed American furnaces. Four hoisting trips are made for one lowering of the charging bell :—

Two hoisting trips of the skip elevate the coke.

Two hoisting trips of the skip elevate the ore and limestone.

Two skip loads of coke or of limestone and ore are maintained on the charging bell to keep it cool.

The hoisting trips are made at intervals of four minutes.

The cubic capacity of the hoisting skip is 240 cubic feet.

The hoisting power is made up of a pair of 14 in. by 16 in. engines geared 6·5 to 1.

An alternative arrangement is to drop the inner rail of the track so that the forward wheels of the skip fall and effect the tilting of the rear wheels, which remain on the ordinary inclined track. No furnace charging arrangement can be considered satisfactory that does not prevent the possibility of the skip being overturned, and the arrangement shown in fig. 4, if properly designed, would make it impossible for the skip to be drawn into the well of the charging bell.

THE UNIFORM CHARGING OF THE MINERALS INTO THE FURNACE.

There are several arrangements in use, designed to secure in a less or greater degree, the uniform distribution of the materials around the main charging bell, so that when the latter is lowered the materials fall in equal proportions all round and from the bell rim, and the burden of the furnace is maintained at a uniform depth.

One arrangement, directly and centrally superposed over the main charging bell, provides a secondary and much smaller charging bell whose well is of sufficient capacity to receive the contents of a specific number of skips. When these skips have been discharged, the smaller bell is lowered, depositing the minerals, etc., more or less uniformly all round the main charging bell. When the main bell is lowered the superposed bell is maintained closed, so that the gas cannot in a serious degree escape from the furnace.* In modern German practice, the charging of the mineral into the superposed bell is also proposed to be effected in such a way as to secure uniform distribution of the mineral on to the secondary bell—this arrangement is shown on page 283. It will be noticed that the charging skip is also equipped with a discharge bell.

Fig. 5 shows another arrangement, in use in American furnaces, having for its object the uniform distribution of the minerals into the furnace. Instead of the secondary superposed charging bell, a mineral receptacle into which the skips deposit their burden is made to revolve horizontally by means of pinion and circular rack gearing, set in motion as the skip descends; each mineral discharge of the skip into the receptacle is by this rotation uniformly deposited on to the bell and all round it. When the well of the main bell has received its full complement of minerals, the bell is lowered, but the gas is prevented from escaping by the rotation of the receptacle which closes off ingress connection to the main charging bell.

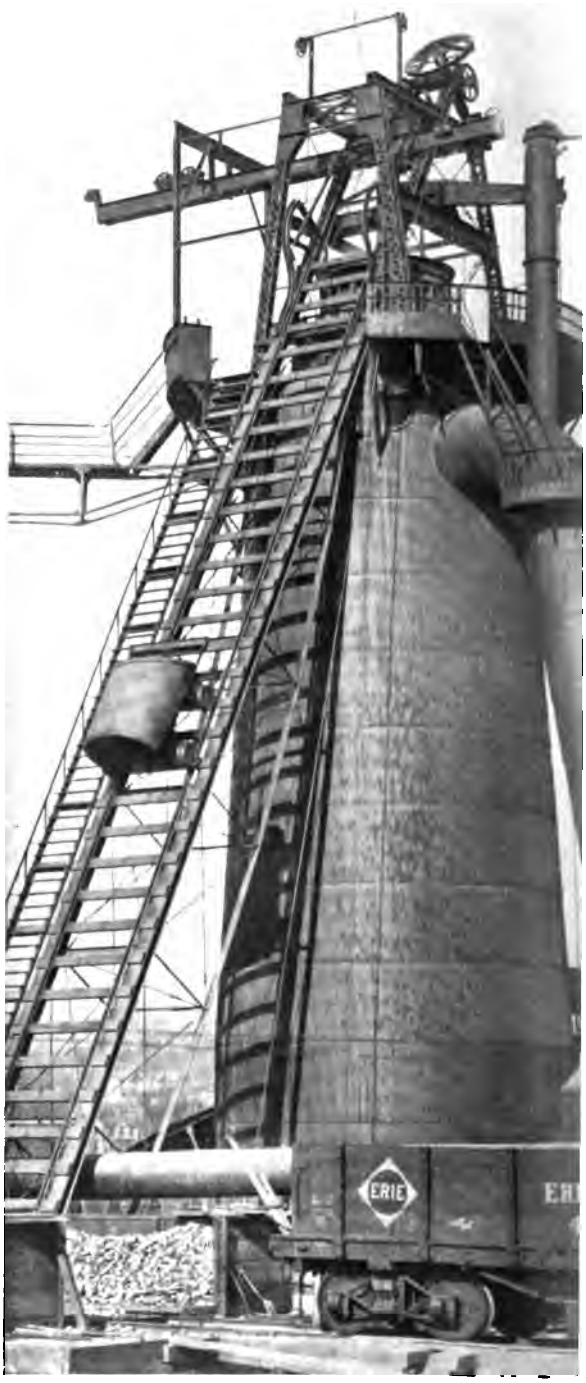


FIG. 4. AMERICAN TYPE OF ELEVATOR AND TOP GEAR WITH ROTATING MINERAL DISTRIBUTOR.

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* The upper and secondary bell receiver or hopper is equipped with readily removable covers, and it can be bodily removed if required.

The receiver is also made rectangular in shape, so that it can receive the contents of two skips.

The well of the main charging bell is equipped with explosive doors.

The prevention of the escape of the gas during charging operations is very desirable, because combustible gas means power, and power means money. Many British furnaces, even now, have actually no charging bell at all, and a great part of the valuable power-gas is thus lost; when such furnaces are closed in, the lowering of the bell means the escape of a considerable volume of gas. The author has designed a secondary and balanced cover arrangement to prevent such a gas escape. (See fig. 6.) The application of the contrivance does not interfere with the existing arrangements of charging.

The direct elevating arrangement shown in fig. 7, designed by Mr. Healey, is an enlarged adaptation of the ordinary bucket chain elevator, and is, therefore, continuous in action.

It possesses the following features: Its continuity of action enables the tare weight of the buckets to be more or less exactly counterbalanced. There is no possibility of overwinding. The energy absorbed in overcoming the inertia of the buckets is reduced to a minimum. The arrangement for the distribution of

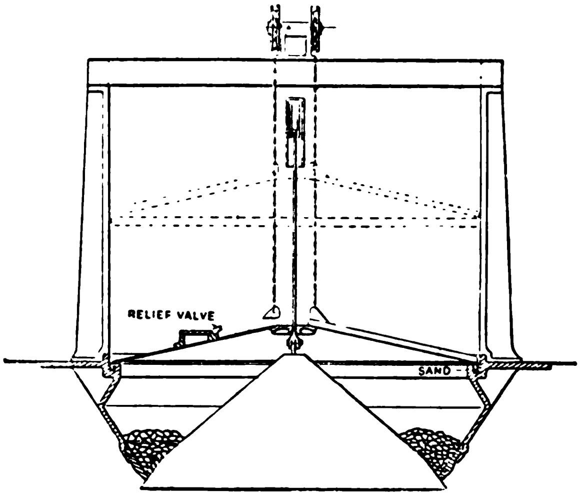


FIG. 6. ARRANGEMENT FOR PREVENTING THE ESCAPE OF FURNACE GAS DURING CHARGING OPERATION, FOR FURNACES EQUIPPED WITH AN ORDINARY BELL USUAL IN BRITISH PRACTICE.

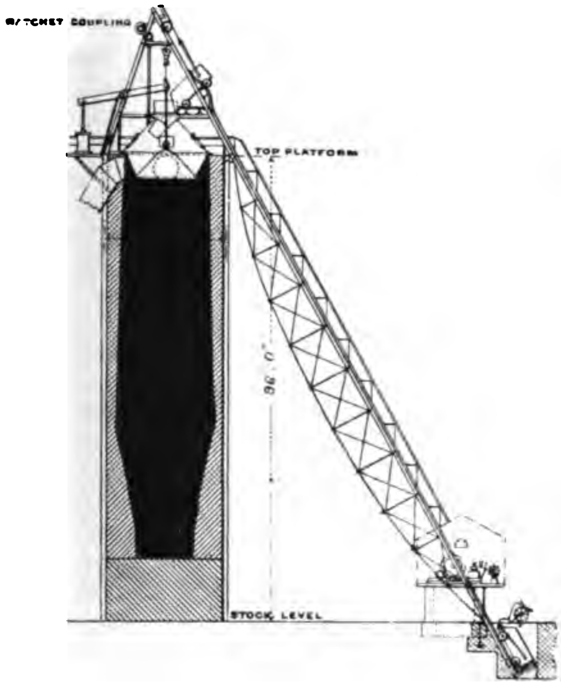


FIG. 5. AMERICAN TYPE OF FURNACE ELEVATOR, WITH ROTATING MINERAL DISTRIBUTOR.

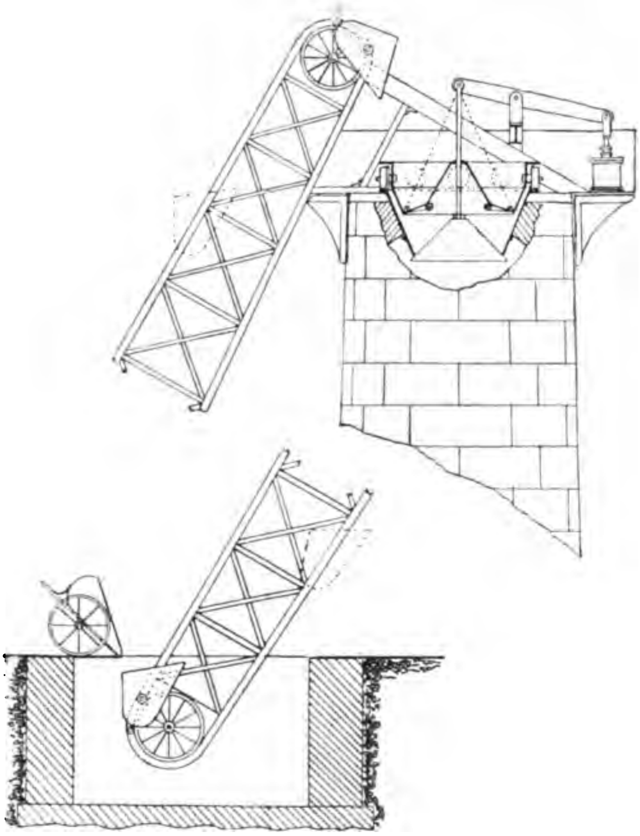
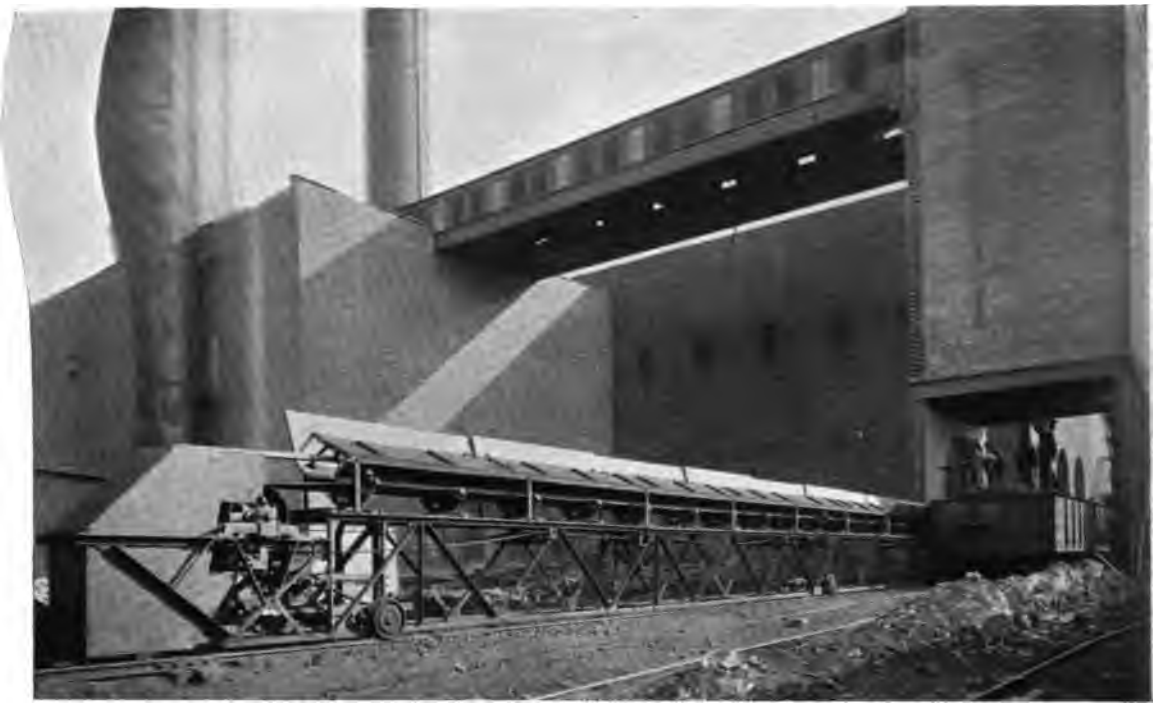


FIG. 7. TYPE OF BUCKET ELEVATOR, WITH ARRANGEMENT FOR DISTRIBUTING THE MINERAL INTO THE FURNACE.



TRANSPORT OF MINERAL ORES ON THE ROBINS' SYSTEM.
Showing the method of transferring the ore from the car to the conveyor.

the charging of the load into the furnace is shown in fig. 7.

Over the main charging bell there is an ore-distributing receptacle mounted on flanged wheels. The receptacle is divided into six compartments, each having its own discharge or bottom door. This receptacle rotates on the wheels on which it is mounted, in such a way that when the skip reaches the top of the elevator incline and is ready to discharge its contents, one of the six compartments is always ready to receive them. The rotation of the receptacle synchronises with the intervals, ascent and discharge of the different skips, the movement of which, ascending and descending, effects the rotation of the distributing receptacle. The opening of the discharge doors of the receptacle permits the mineral to fall on to the main charging bell, but when the latter is lowered the discharge doors are closed, thus preventing the escape of the gas during the operation. The elevation of the bucket should automatically register its ascent and the fact that it is loaded.

The development of the ordinary chain elevator type in recent years has been extremely great, and in that of the Robins' type particularly. This exceedingly efficient method of transportation is in common use for transporting ores. An example of its application to the transport of iron ores is shown in the accompanying illustration. In the frontispiece will be found an illustration of the Robins' Conveyor, showing the transfer of the mineral over an incline having a very considerable gradient.

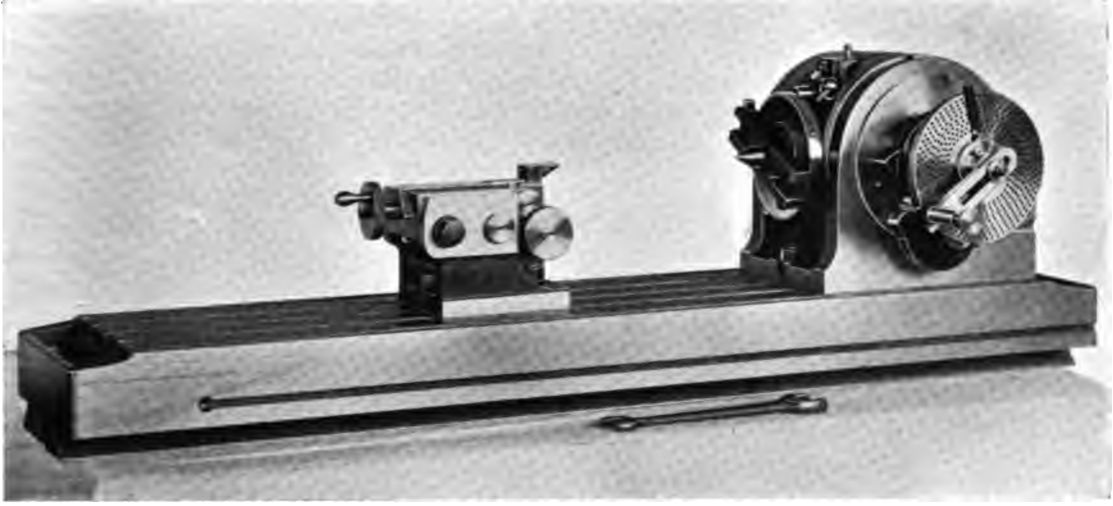


FIG. 2. NEW DIVIDING HEAD AND TAILSTOCK FOR CINCINNATI UNIVERSAL MILLING MACHINES.

MILLING MACHINES.

BY

JOSEPH HORNER.

Deals with the Universal Indexing and Dividing Heads, Tailstocks, and other Fittings.

III.

A GOOD idea can be gathered of the general construction of milling machines from photo illustrations. But there are certain details which cannot be understood or explained clearly without detailed drawings. Chief among these is the Universal Indexing and Dividing Head, which is one of the most remarkable elements in machine tool design, by reason of the very high degree of precision embodied in it. The same remark applies to feeds, to be considered in another article.

A machine is rendered universal by the fitting of a spiral head and index plate, in conjunction with a swivelling table and change gears. The index plate gives divisions of a circle, and change gears impart the spiral movement while the table is being traversed by the feed screw. Though there are similarities in external appearance in most dividing heads, yet there is a good deal of difference in detail and in workmanship. We cannot do better under these circumstances than illustrate one of the best and latest types with sectional views, that of the Cincinnati Milling Machine Company, of Cincinnati, Ohio.

THE CINCINNATI UNIVERSAL HEAD.

The general appearance of the machine itself as now made by the firm, is seen in fig. 1, the head and back centre, are shown in the photo fig. 2, while the detail drawings of the head are given in figs. 3, 4, 5. Fig. 3 illustrates the head and tailstock in external elevation, and figs. 4 and 5 are sections of the former in the longitudinal and transverse directions respectively.

Distinctive features of this design are the following :—

The swivelling block, A, which carries the spindle, B, makes a complete revolution in the

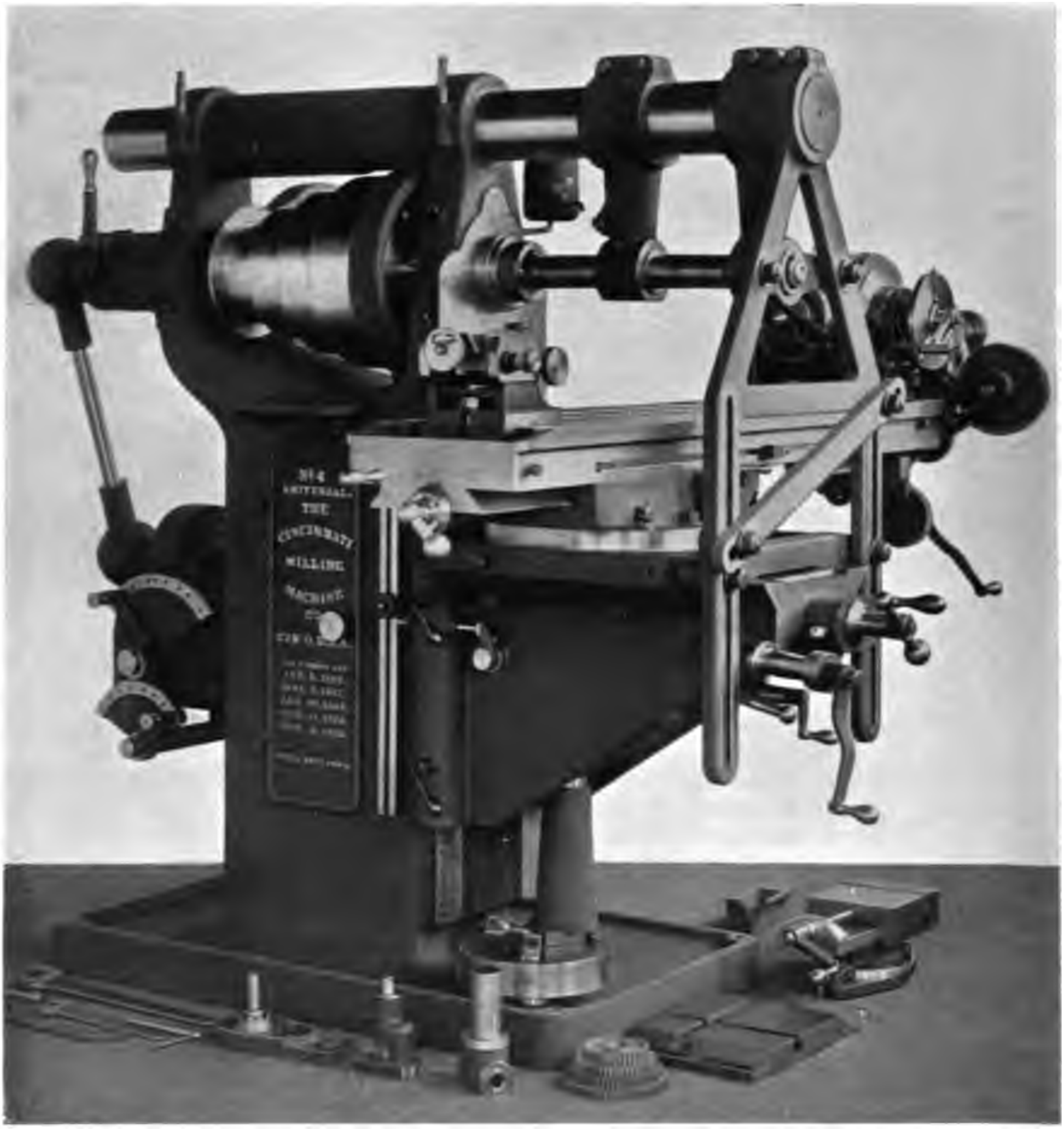


FIG. 1. THE LATEST PATTERN CINCINNATI UNIVERSAL MILLING MACHINE. THE CINCINNATI MILLING MACHINE CO., CINCINNATI.

vertical direction. This it has in common with some other modern heads, but in general the movements of heads are confined to angles ranging from 10 deg. below the horizontal and 10 deg. beyond the perpendicular. And when cutting spirals the movement is still large, ranging between 5 deg. below the horizontal to 50 deg. beyond the perpendicular. The capacity for complete revolution is in some cases an advantage, because it permits of the cutting of right- and left-hand work without changing the cutter, and the cutting of the same piece of work on either side of the perpendicular. Moreover, the swivelling block is contained wholly within its bearings at whatever angle it may be set. By means of a new clamping arrangement it is held securely in any position without strain being thrown on the spindle. This comprises two trunnion bearings on the swivelling block, embraced by the clamping rings, C, pinched by two cap screws, D, the action being similar to that of clamping a shaft tightly in its bearings. In this case the circumference of the trunnion is very large, with the result that no disturbing influence can possibly affect the spindle or the worm gear. The edge of the swivelling block is of course graduated into degrees.

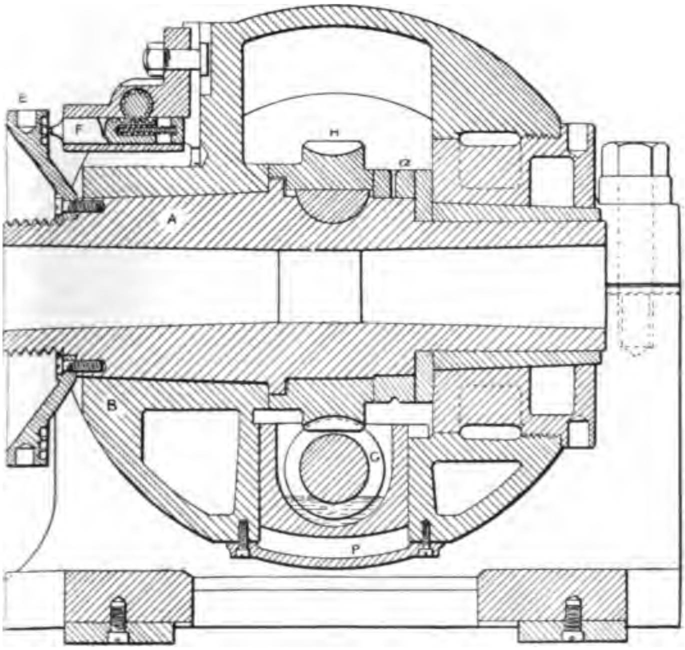


FIG. 4.

The spindle, A, is provided with a clamp ring at *a*, which secures it endwise, and does not disturb its accuracy. The coned bearing neck at the front and the coned bushing at the back afford provision for taking up wear. The hollow spindle has a tapered hole in front.

THE DIVIDING MECHANISMS.

These include the worm and wheel, and a special and very convenient index plate, E. The latter is used for getting low numbers in order to avoid the risk of mistakes that sometimes occur in counting the number of turns of the worm for low numbers. Divisions under 40 are obtained with this plate. On all divisions of 40 and over, more than one turn of the worm is not required.

The plate, E, for direct indexing, is dish-shaped, and has three circles of holes, 24, 30, and 36 on the back, in a position where they are protected from dirt and chips. This, with the adjustable pin, F, is seen in sectional detail in fig. 4. The pin holes for 4 and 6 divisions, which are so frequently required for fluting, nut-making, etc., have their positions indicated on the edge by figs. 4 and 6, so saving the trouble of counting the holes. This plate has a further and subsidiary utility, since when it lies in a position approaching to the vertical it affords protection to the cutting head from falling chips and oil.

DISCONNECTION OF WORM AND WHEEL AND THEIR ADJUSTMENTS.

The worm, G, and its wheel, H, are seen in gear with each other in the drawings. To effect their disconnection the worm is dropped bodily in its bearing or case, J. This, it must be noted, is a vertical movement only, and not an eccentric one. It is effected by the eccentric pin, K, that moves the case bodily up or down. As the latter is confined sideways, the eccentric end of the pin is inserted in a bushing, L, which has endlong motion in the worm case, and so produces the motion.

The screws, M, tie the worm case to the block above, which is drilled

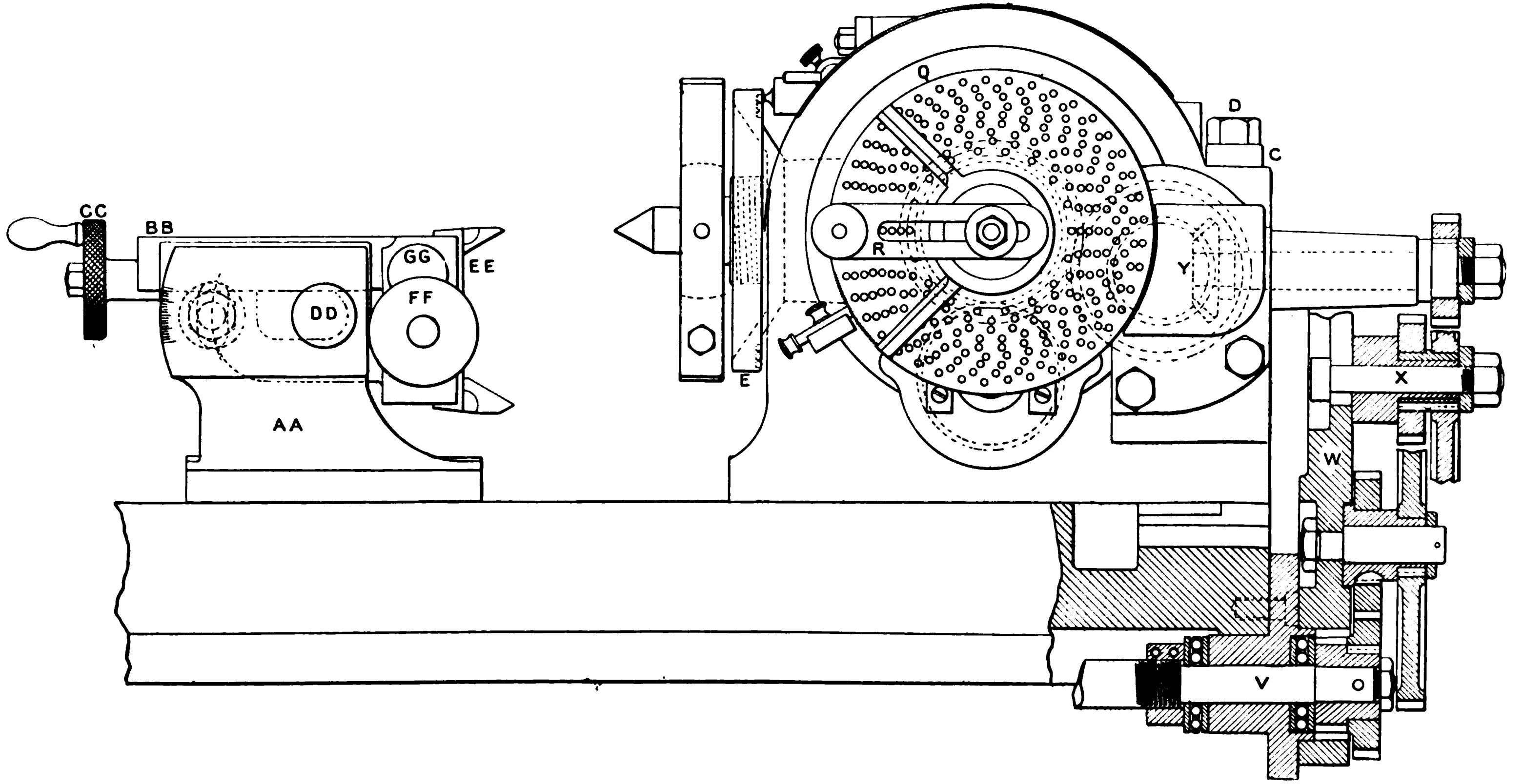


FIG. 3. HEAD AND TAILSTOCK IN EXTERNAL ELEVATION.

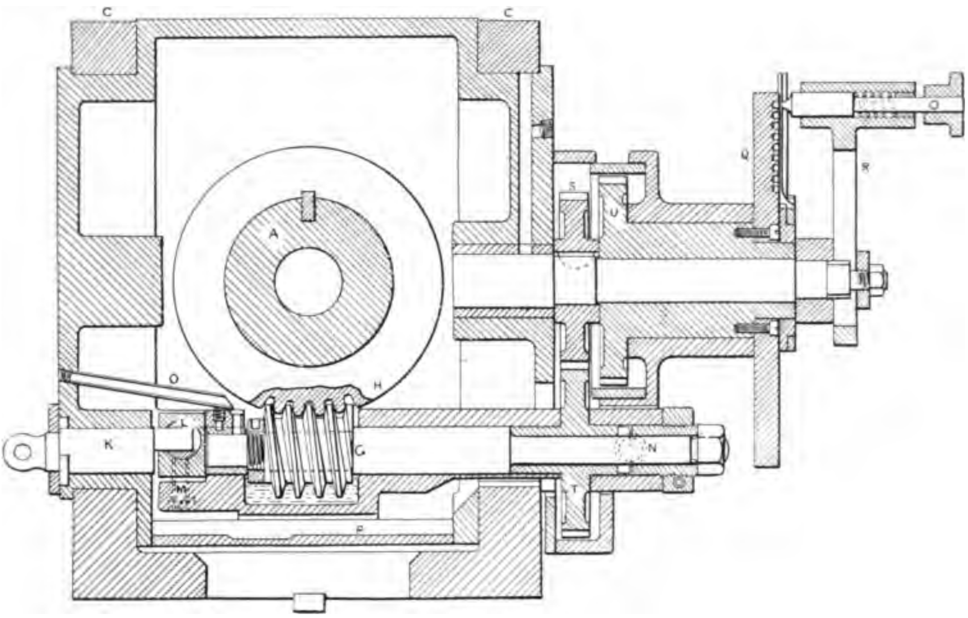


FIG. 5.

for L, and by means of these screws the worm is adjusted to the wheel. This is a straight line movement, as it should be. At the other end the worm case swivels about the pin, N, as a centre.

There are thus two separate adjustments provided, and each in a straight line, that for taking up wear by the screws M, and that for engagement and disengagement by the lever, K, and sliding pin, L, both of which are ideal arrangements, theoretically correct.

The worm is single-threaded, and right-handed, with two and a half threads per inch. It runs in a bath of oil supplied through the tube, O. The cap, P, can be removed for purposes of cleaning and examination. The wheel has the usual forty teeth, so that forty turns of the handle, R, move it through one revolution. Both it and the index plate are of good size.

THE INDEX PLATE.

The index plate, Q, is drilled from both sides, so that when reversed it provides a large number of divisions without having to use extra plates. Extra special plates are however provided for effecting divisions that cannot be obtained directly from the standard plate which is furnished with a machine—the principle being the addition or subtraction of fractions—adding or subtracting two indexings. Such divisions have hitherto been obtained by the tedious method of compound indexing. The work is rather puzzling to the uninitiated, and a description of it would encroach too much upon the space at our disposal.

The dividing or indexing head is used on plain milling machines as on universals, but the change gears for spiral work only upon the latter. The illustrations, figs. 3 and 5, render this distinction clear. In fig. 5 the revolution of the handle or index pointer, R, turns the worm and its wheel through equal gears, S, T. When spirals are being cut the worm is driven through the gear, U.

THE CHANGE GEARS.

The connecting up of change wheels from the lead screw, V, is illustrated in fig. 3, W being the swing plate, and X one of the two studs for compounding trains. The motion is transmitted to the spindle at right angles by the bevel wheels, V, actuating the spur wheels shown in fig. 5. The dotted lines of these bevel wheels are seen in fig. 3, in which details may be noted, by the way, of the ball thrusts to the lead screw, Woodruff keys to the worm wheel, and some of the fixed gears; also a fine adjustment of the index plate by ratchet and pin for resetting work. But we must now give some attention to the methods of operating this piece of mechanism.

THE METHOD OF INDEXING, AND OF CUTTING SPIRALS.

We start with the fact that the arrangement of gears permits the spindle to be rotated automatically at whatever angle it may be placed, that the index plate gives equal divisions, and that the change gears impart a rotary motion to the spindle, the amount of which bears a relation to the pitch of the lead screw. As the worm thread and the worm teeth are as one to 40, forty revolutions of the wheel to one of the worm form the basis of calculation. The value of the index plate used in conjunction with this lies in making sub-divisions when the crank or pointer has to make less than a complete revolution to effect the required division. Thus, forty turns of the crank effect one revolution of the main spindle, and one turn would effect a fortieth of a revolution of the main spindle, and therefore this operation would have to be repeated forty times to obtain forty divisions to the circle. To obtain eighty divisions the crank would be turned but half way round for each division; to obtain twenty, two turns would be required. Hence the rule—divide 40 by the number of divisions required, and the quotient will be the number of turns or parts of a turn which will have to be imparted to the crank. Thus—

$$\frac{40}{40} = 1 \qquad \frac{40}{80} = .5 \qquad \frac{40}{20} = 2$$

Or, taking a number, say 144, then $\frac{40}{144}$ may be reduced to $\frac{5}{18}$, which means that the crank must be moved $\frac{5}{18}$ of a turn.

THE SECTOR.

In getting into these fractional parts it is necessary to select circles of holes which are either of the number required, as 18 in this instance, or a multiple of the same, as 36, 54, 72, etc. Here the value of the sector comes in,

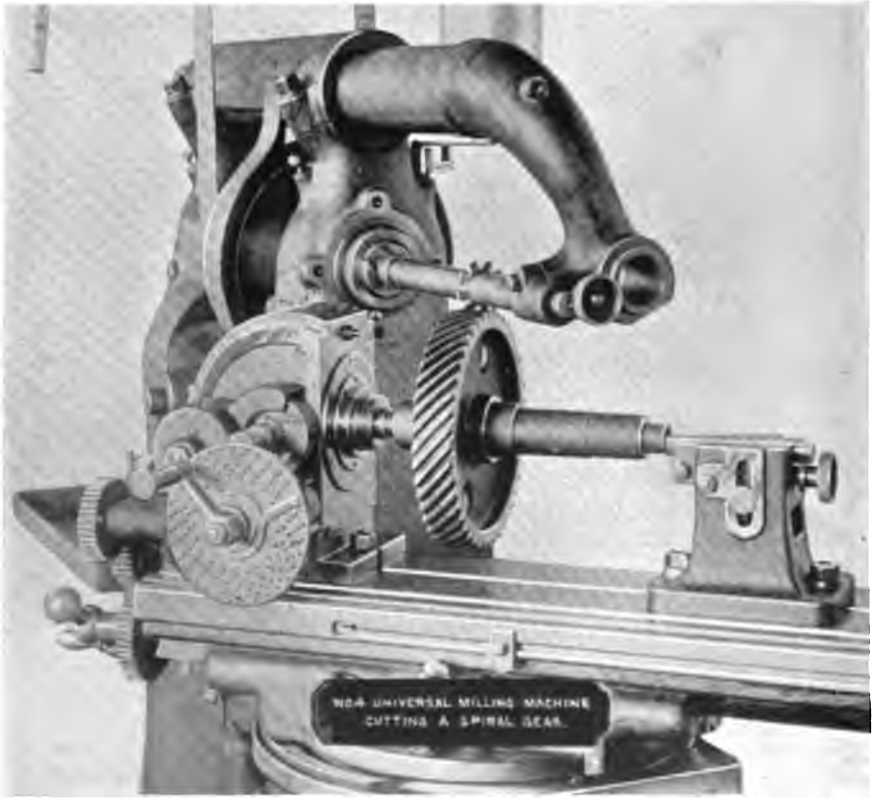


FIG. 6. CUTTING A SPIRAL GEAR ON A BROWN AND SHARPE UNIVERSAL.

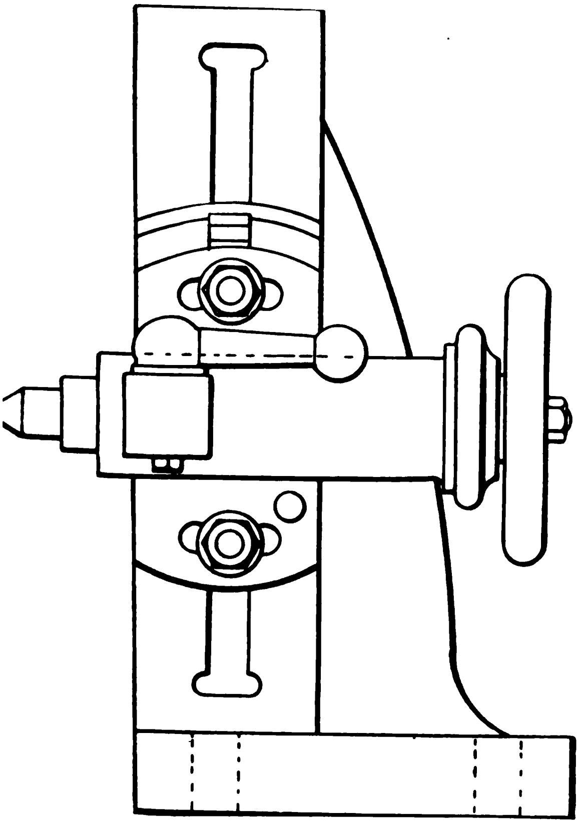


FIG. 7. TYPE OF TAILSTOCK IN USE ON THE CONTINENT.

because the counting of holes is liable to error. Having a sector once set to, say, every fifth hole in the 18 hole circle, or tenth hole in a 36 hole circle, further risk and trouble are saved. The sector is seen in figs. 2 and 3. It is set to one hole more than the spaces to be counted, and there clamped. That is, the hole in which the index pin enters is not counted, but the 5, or 10 holes, or other numbers as may be required are counted apart from this one. When the sector is tightened with its screw, no further counting is necessary, but it is simply moved against the index pointer for each division. When this has been repeated the proper number of times, and a cut made at every setting, the main spindle in the dividing head will have made one revolution.

To facilitate this work, and save the labour and risk of calculation, is the reason why index tables are furnished, which give opposite the number of divisions required the number of holes in the index plate which may or should be selected, and the number of turns of the crank required for the circle of holes given. These tables may, of course, be used merely as a basis to work upon, other circles and numbers of turns being easily deduced therefrom.

METHODS OF CALCULATION.

The dividing head used alone finds its applications in fluting taps and reamers, in cutting wheel teeth and ratchet teeth, etc. But for spiral teeth, and for twist drills and spiral milling cutters, the spindle must be rotated by the change gears. These are exactly the same as for screw-cutting in lathes, but the subject is approached from a rather different standpoint. Thus, instead of taking the pitch of the screw or spiral as the basis, the distance through which the table travels during one revolution of the spindle in the dividing head is given, and this is termed the lead of the spiral. If the spindle makes one turn to 6 in. travel of the table, the lead is 6 in.; if one turn in 10 in., this is a lead of 10 in. The calculations involved are simple, because the lead screw usually has four threads per inch, and forty revolutions of the worm are required to impart one revolution to the spindle of the dividing head. If gears of equal diameter were put on the lead screw and on the worm shaft, the lead screw would therefore have to be revolved forty times to rotate the worm shaft forty times, and in that period the table would travel 40, divided by its pitch 10 in. Other gears are obtained by multiplying the required lead in inches by 4.

Having obtained the ratio in the form of a fraction, the latter is divided into two, as in screw cutting, and the numerator and denominator of these fractions are multiplied by a number to give numbers of teeth of wheels in the set available. This applies to compound gears. In a simple train two wheels give the ratio, one going on the worm shaft, the other on the lead screw, with an intermediate, which, of course, may be of any size, to connect them.

The setting of the table to the angle of the spiral to be cut is obtained either graphically or by the aid of tables. In the first case, the hypotenuse of a triangle is taken, one side of which equals the lead, the other the circumference of the spiral. In the second case, the circumference is divided by the lead, and the quotient compared with a table of natural tangents, and the table set to the degrees obtained. Or a table is consulted which gives a wide range of angles for different spirals.

Fig. 6 illustrates the cutting of a spiral gear on one of the Brown and Sharpe universals. In this head the spindle is rotated in a curved seating in which it is clamped. The spindle can be rotated independently by the worm and wheel, since the worm can be thrown out of gear with the wheel by an eccentric bushing. The spindle may then be turned by hand and locked by the index plate and pin. In the head for the No. 1 or smallest machine, steel bushings afford a bearing for the worm shaft, and a pivot for the spindle box, and the front end of the latter is set by suitable graduations to any angle from 5 deg. below the horizontal to the perpendicular. In these heads the worm wheel has forty teeth, and the worm is a single-threaded one.

A special spiral head by the Cincinnati Milling Machine Co. is designed for cutting coarse spirals, for which it is better adapted than the regular head. The worm is double threaded, and of 1½in. pitch, and the wheel is 8¾in. in diameter.

PLAIN INDEXING CENTRES.

These are used on both plain and universal machines. Division is effected by plates and index peg. Two plates are fitted in the Cincinnati, one for getting all odd divisions up to 50, the other all even divisions up to 100. The spindle is hollow, with a standard taper at the front end. The nose is threaded and covered when the chuck is not in use. To relieve the index pin and plate from strain, the spindle is clamped firmly in position during cutting. To extend the range of service, raising blocks are fitted for increasing the height of centres.

THE FOOTSTOCK.

When work has to be carried at each end, as in fluting taps, reamers, drills, cutters, etc., the tailstock or footstock is used in conjunction with the dividing head. This is seen in figs. 1, 2, 3, and 6. That of the Cincinnati Company is seen in some detail in fig. 3. The housing, AA, carries the longitudinal slide, BB, which fits into it with a dovetail, being traversed by the knob, CC, and clamped by the bolt, DD. The centre bar, EE, is double-ended, one end having an ordinary centre for heavy work, the other being reduced on the top face to enable cutters to clear when fluting, which frequently approaches very near the centre of the work. The position of the bar is readily reversed. It is adjustable vertically with rack and pinion, actuated by the knob, FF, and clamped by the bolt, GG. The centres can also be tilted forwards, swivelling about the centre, DD, graduations on the housing giving exact angles. The Brown and Sharpe footstock is made on another pattern. Two taper pins are used to adjust the centre in line with the headstock centre. To set it at an angle, a rack and pinion are used. The centre is clamped firmly by three nuts.

A different type of tailstock, fig. 7, is common on the Continent. It comprises an upright on which a swivelling block that carries the centre is adjustable vertically, a screw being frequently used for convenience of moving the block. The latter is made to swivel for the purpose of

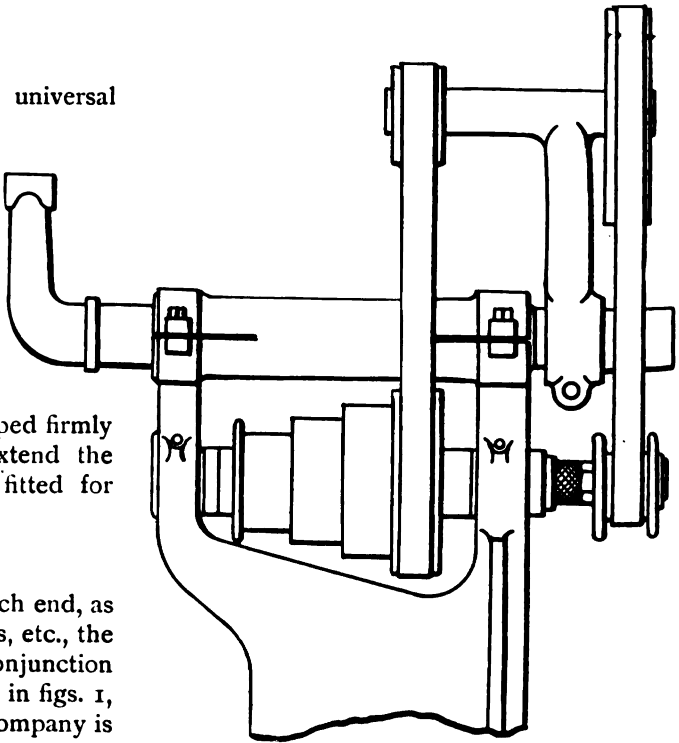


FIG. 8. HIGH-SPEED FITTINGS.

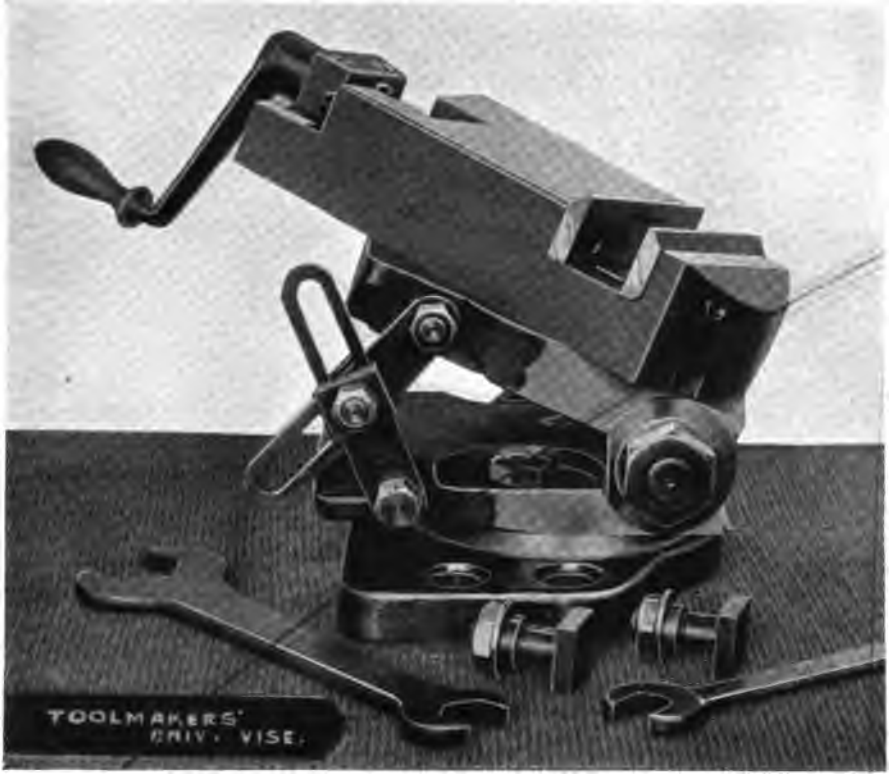


FIG. 9. TOOLMAKERS' UNIVERSAL VISE FOR BROWN AND SHARPE MILLING MACHINES.

supporting the outer end of taper work, when the taper is long, and the angle large. It provides the same movements as the American and English patterns, but a screw is used instead of a rack for the vertical movement, and the mechanism is entirely different.

OTHER FITTINGS.

There are numerous other attachments made to plain and universal machines with the object of increasing their range of service. They generally comprise a high speed fitting, and a rack cutting attachment and vises. Frequently also a table for rotary milling, a cam cutting device, a vertical spindle, and a universal attachment.

The high speed fitting, fig. 8, is used for light end mills chiefly. It comprises a spindle which runs in a shell that fits the taper hole in the main spindle. It is driven by a belt from above, which is operated by a belt and pulley driven from the headstock main cones. The pulleys have their bearings in a bracket, which is clamped on the overhanging arm standing above it, or some equivalent device. Speeds of over 1,500 revolutions per minute are thus obtainable.

In a rack cutting attachment a pair of bevel gears changes direction of motion from the spindle to the rack cutting spindle and arbor running parallel with the table. The advantage of changing the axis is that there is no limit then to the length of rack it is possible to cut. The racks are held in a specially long vise. By fitting a slitting cutter, stock can be sawn off by the same attachment.

A circular milling attachment is often very valuable for conveniently doing work that would otherwise go to the lathe.

Rectangular vises are made in various designs to bolt to the machine tables to hold work parallel with or at right angles to the table, to swivel to horizontal angles or to vertical angles, and having graduated edges. One of these, by Brown and Sharpe, is shown in fig. 9.

(To be continued.)

EXAMINATION OF PATENT SPECIFICATIONS.

BY

JAMES SWINBURNE,

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ARGUMENT. Examination with guarantee by State. Examination as to novelty without guarantee. Popular idea as to simplicity of examination. Inventions, matters of degree. Differences, small on paper, determine great commercial advantages. Danger of undeserved monopolies when the State guarantees. Danger of ill-advised rejection. Impossibility of settling novelty at date of application in certain cases. Present fees not paid as price of monopoly, but to cover office expenses, and to go to the Treasury as tax on industry. German and American practice.

THERE are a great many incompatible theories as to what the Government ought to do for patentees. Some people hold that it is the duty of the Government, or rather of the State, by means of its patent office and its officials, to examine an applicant's specification thoroughly and completely, and if it covers a good invention, to protect the patentee from all infringement; all examination and subsequent legal proceedings being borne, as to expense, by the State, that is to say by the public. Others, who do not go quite so far as this, hold that the patent fees paid by the inventor should cover the cost of examination, but the cost of the proceedings against any infringer should be borne by the State. Another idea is that the fees should be in excess of the office expenses, the balance of all the fees being pooled as a fund to defray expenses of prosecuting infringers. The other extreme of view is that the patent office should not examine at all, but should grant an apparent monopoly to anyone who asks for it, or what is much more important, who pays the fee for it.

For typical examples we may take as one extreme Germany, where there is a very thorough examination, and the State protects the patentee. England, where they charge fees in excess of the expenses, and make a small but useful examination on some points, is almost extreme in the other direction. The present examination in England is rather peculiar; it has eventually developed into an examination as to the form of the specification, and it is really a great benefit to inventors. There is a Bill to alter the examination now before the House of Commons. This will be mentioned later. The United States stand between, as they make a thorough search as to novelty, but do not guarantee the patent when at last issued.

POPULAR NOTIONS FALLACIOUS.

The whole matter is not nearly as simple as it sounds; and it is probably owing to people treating a complicated matter as simple that so much difficulty and misunderstanding has arisen, and so much misguided legislation has come about. It is so easy to decide that there shall be a number of clever technologists employed as examiners, and that they shall look through each specification and say at once the invention is new, or that it has been anticipated by this or that. In all such cases people have in their minds a specification clearly describing some clear-cut, definite invention, and claiming it, so that the region claimed is perfectly determined, and the specification can be compared with every prior description of anything at all like it, in such a way that a competent examiner can decide without doubt whether the invention is new or old. But anyone who has had any experience of real patents knows that the matter is not simple. Inventions are invariably matters of degree. The Heaven-born genius who comes along with a brand new invention which has nothing to do with anything that went before, and which is completely worked out and in its final and only possible form, exists only in imagination. Take actual applications. There can be no doubt that nine-tenths of the patents taken out would not hold water if they came into court, but the rest, the other tenth, would involve enormous research and very great critical acumen to determine whether they are valid or not. But even the ninety per cent. that are certainly invalid would give great trouble to examiners. Many of them are invalid through being drawn up by ignorant inventors who make technical slips and all sorts of blunders. Under examination, and the resulting correspondence, the grosser errors would be removed, and the more difficult questions of novelty and subject matter would come up.

EXAMINATION ON PUBLIC GROUNDS.

In considering the question of examination, we must deal with the matter first from the public point of view. That is to say, the patent office should be self-supporting, but it should encourage invention to the greatest extent possible, without unduly hampering trade by giving undeserved monopolies. We will therefore assume that the patent office is self-supporting, that is to say that all expenses are paid out of patent fees. We need not assume that a surplus is handed over to the Treasury; that, as was pointed out last month, is a piece of political immorality of a particularly pernicious type, as it is a taxing of industry.

THE PATENTEE'S STANDPOINT.

Next we have to look at the question from the patentee's point of view. Patentees may be broadly divided into two classes, though there is no sharp division. On the one hand, we have the experienced specialist who is improving his own branch of applied science. Such a man is well up in the theory of his work, is practically familiar with all the working details, so that he appreciates the great practical differences between matters that look almost alike on paper, and he is also well up in the history of his particular branch of art, and knows not only what has been done in the past, but has a close acquaintance with all that is going on at the time he applies for his patents.

Opposed to this type as the opposite extreme, we have the ignorant inventor, generally overburdened with conceit, who takes out patents on all sorts of things belonging to all sorts of industries. He does not know what has gone before or what is already done, but he believes he has a sort of superior insight by which he can teach other people anything. He may be a schoolmaster, or a stockbroker, or a clergyman, or a mere genius. Another more pleasant and perhaps commoner type of inventor is the so-called practical man, who really does not understand his own work, and stumbles along with tremendous perseverance and often under very difficult pecuniary conditions. Most of his patents are waste paper, but every now and again he makes a real invention of great value.

SKILLED SPECIALISTS AND PATENT AGENTS.

Take the skilled specialist inventor first, and see how far examination will help him. Such an inventor generally employs a patent agent, and his specifications are not likely to contain legal flaws, unless the subject is exceedingly difficult. It has been said, and rightly said, that most of the big patent cases have been about the interpretation of specifications that have been bungled by patent agents. That only means that the good specifications which they have not bungled have not come into court. The work of the patent agents, or at any rate of those that are high in their profession, is very well done, and the younger men who have come into the profession after a pretty stiff examination will gradually raise the profession further. The patent agent is, however, in a difficult position, and we may make an apparent digression on this point, as it touches on official examination. To go on with our intelligent inventor. He is working at a particular subject, he is taking out a patent every few months; he has not unlimited funds. He does not know which of his patents will eventually be valuable. He goes to a first-class firm of patent agents. They charge him, in addition to the Government fees, perhaps eight guineas per patent. If he has special work done he, of course, pays more. Now, this eight guineas, or whatever it may be, is a fair charge for ordinary skilled assistance. Eventually the question of the validity of one of the patents may be a matter of many thousands of pounds, and when it comes into court the inventor would give any money to be able to re-draw his specification. But he cannot have each of his patents examined carefully by highly-skilled, trained intellects, nor can he afford to have all his claims settled by counsel and so on. The result is that, however able the patent agents may be, they cannot ordinarily examine and draw all their specifications with the care that a valuable invention deserves, because the inventors cannot generally afford the money necessary, or even if they can afford it, do not consider it a good investment to spend so much on a large number of patents of which few, if any, will eventually become valuable. The popular idea is that an inventor invents one definite thing and takes out one patent, and a new manufacture comes into being. But, in fact, the inventor develops his ideas over many years, and is continually taking out patents all the time. His first is a rather broad patent. Then he takes out patents for details. Then he finds his first patent is not broad enough, and takes out more patents over the various parts of a larger area, and so on. He cannot tell which patent will eventually be valuable, that is to say, which will really stop a future infringer, who is himself an inventor, and tries to get as far away from the protected region as he can. It is thus impossible for the patent agent to do more than to make the inventor's specification clear and intelligible as well as legal in form, and to help him by friendly criticism and by advice as to the best way to draw the specification claims.

EXAMINATION WITH GOVERNMENT GUARANTEE.

If the patent office undertakes examination and guarantees the patent, it must do a good deal of the patent agent's work, but not in a way that helps the inventor. For the examiners could say what is wrong, but it would not be their business to advise the patentee and tell him how to put his specification right. But the broad difficulty is that it would involve waste of time and money; for each of a number of patents, of which most will never be of any value, will have to be examined in great detail. If it does not pay each patentee to examine his specifications in this careful way, it can hardly be policy for the State to do so. If the State is to guarantee the patents, every patent must be examined and criticised with as great care as it now is when a patent action is fought. Assuming that examination by patent action is ruinously expensive, it still must be very expensive to examine properly by means of organised trained examiners, and it is waste of money to devote this expense to all patents. But does the skilled inventor want examination? As far as novelty and the real nature of his invention goes, he must know far more than the examiner. Take, as an example, any new industry or development; imagine the inventor is an expert in wireless telegraphy, and has been devoting his whole time for some years to working out his inventions, studying the very difficult theory of his subject, and watching the development of his specialty at the hands of rival inventors from week to week. He must know much more about his patents than the patent office examiner. I do not know who is the examiner in wireless telegraphy, but if he is as competent as the other examiners are, his subject is in good hands. But it is nothing against him to say that he cannot be expected to know as much about his subject as our inventor. It would not be surprising if there is no special examiner in wireless telegraphy that is to say, no examiner who devotes his attention, like our inventor, exclusively to that one subject. The question, in the case of Government guarantee, would be whether the inventor is to have his patent accepted or rejected finally by the examiner. The examiner would have an enormous responsibility on his shoulders. He must deal with a number of patents every day, and he must remember that every time he accepts one he is rendering the State liable to have to support his grant of monopoly, and he may be crippling new industries by granting monopolies to people who have not really done anything to deserve them. His interest, therefore, must be to reject whenever he possibly can, on the one hand. On the other, this cuts down the flow of fees to the department.

WHAT IS NOVELTY?

Reverting again to the popular notion—the idea as to novelty is that there is or is not a clear prior publication of the exact thing, and that the examiner has merely to look up earlier documents and see if the invention has been described before. This, again, has nothing like it in fact. There is almost never an exact publication of the most obvious invention; there is only something more or less like it, or several things resembling it in various different ways. The question is, then, whether the inventor has or has not made an inventive advance. This is a matter of judgment, and generally a very difficult matter of judgment. When a case is fought in court, generally many years after the date of the patent, when the advances are really made, and are not mere speculation, it demands a number of the ablest counsel, and the most experienced technologists as witnesses, and any time up to three or four weeks is occupied in the discussion. Admitting for the moment that the proceedings in the courts are cumbrous and expensive, they still show that the investigation of the novelty—for that is generally the main point at issue—is a very difficult matter indeed. Much more difficult is it, then, when the invention is quite new.

As one example of the difficulty of settling novelty we may take a patent for something which appears so obvious that it must be old If the article was not in use at the date of the patent, and has come into general use afterwards, the courts hold that that is proof of novelty, as the article was evidently wanted, and if it did not come into use before the patent, it must have been new. This test of novelty is obviously inapplicable at the date of application and in any case the examiners would not be in touch with industry. Such an application as this would be rejected, doing a great injustice to the inventor.

EFFECT OF UNFAIR MONOPOLIES.

No doubt many people will say that when there is any doubt the patentee should get the benefit. This is unsound, however, as a matter of public policy. It is obviously wrong to give a monopoly, or power of stifling an industry, to a man who has invented nothing. Even if we look at it only from the point of view of the inventors, it is wrong. Each patentee stands in the way of all subsequent inventors. If an early patentee, who files an unpractical specification, for example, is given a guaranteed monopoly, it practically stops all future invention. One of the most difficult questions, apart from novelty, is whether a specification describes a workable thing in language clear enough to be understood by specialists in the industry. Even after many years it is often difficult to decide whether a specification is practical. How an examiner, dealing with a completely new subject, is to say whether the proposed invention is practical or not, it is impossible to conceive.

SKILLED INVENTOR AND EXAMINATION.

Now consider again the skilled inventor. Ought his fate to be entirely in the hands of an examiner to whom his specification is only one of many coming before him daily, or should he be allowed to use his own judgment and knowledge? The inventor will naturally say, "I understand my invention much better than the examiner can, however able he may be, because I am a specialist in this subject. My invention is merely a small incident to him; to me it is a matter on which a fortune probably depends. He has brought forward an early specification which vaguely describes something like my invention, but further understanding of the subject, especially the practical working of my invention, would show he is wrong. I would therefore prefer no Government guarantee of my patent against the public, or of the earlier patents against me. I would rather trust to the full but expensive investigation in the law courts, if there is any question of the validity of my patents later on."

FEES AND WASTE PAPER.

But the skilled inventor only represents some small fraction of the applicants for patents. The result is that the patent office at present takes fees for, and accepts many thousands of specifications which are waste paper. But does this matter very much? We often read letters from people who complain that the patent office has no business to accept fees for patents which the officers know or ought to know are worthless. But this is a wilful misunderstanding of the relation of patent fees to patents. The fee is not the price paid for a monopoly. The fee is nominally to cover office expenses. It is really also a tax on industry. But it must be admitted that if this tax were removed we would have still more useless patents. The price the inventor pays for his monopoly is the work he has devoted to his invention, not the fee he pays for the formalities of the office. To say that the State should guarantee patents because they charge £4 fees is analogous to saying the State should guarantee that an agreement is not broken if money has been paid for a stamp, or that a limited company is to be financially sound because the Somerset House fees have been paid. To pass thousands of patents, most of which will be useless, may do comparatively little harm. But to go to the expense of examining all of them seriously, and discussing patents for inventions which will be immediately superseded by better inventions, with the care that ought only to be spent on really important matters, means very serious waste of public money. The patent office ought not to be an organisation for the assistance, by advice, of incompetent inventors. Many inventions now are really due to the patent agents, who lick their clients' work into shape and cut out useless things and straighten out the inventors' ideas in a logical way. It can never be the duty of a Government department to do this for muddle-headed inventors, and in practice patentees are often muddle-headed. In short, to recapitulate, examination combined with Government guarantee of the patent means that there will be a tendency to disallow good patents; that industry will be hampered by the allowance of bad patents; and thorough examination will be impossible, and what examination is possible will be much more expensive than will pay.

GERMAN AND AMERICAN METHODS.

It may be urged against these conclusions that Germany does examine, and Germany does guarantee patents. But no one who has had to do with the German Patent Office would say the system is satisfactory. Both in Germany and in America it takes a great deal of energy and considerable perseverance and an appreciable pecuniary depletion to get a patent through. It is not the fault of the examiners, they have an exceedingly difficult task. The great difficulty is to explain differences that are vital in practice, but do not look important on paper. A patent for using tinned iron wires for sealing into incandescent lamp bulbs, for instance, was rejected because a paragraph in a paper said that a fusible alloy of tin and some other metal adheres to glass. The alloy, of course, could not be sealed into a bulb, as it is fusible; but clearly the examiner did not understand anything about incandescent lamp problems. An appeal might have been lodged, but then the matter would have been referred not to experienced technologists but to some university professors who would have no knowledge of the subject at all. This would have cost more, too. Finally, somebody else invented a better wire, so there was no real loss except the labour of trying to get the patent through, and the cost of examination to reject it. If I remember right, Germany does not trust the examination entirely. A patent may be questioned as to validity during the first five years of its life by outsiders. This is obviously wrong. Either the examination is thorough or it is not. In practice, of course, it is not. But why should a bad patent become good because no one has been interested in opposing it for five years? An industry may develop slowly, and perhaps in another country. When it is developed the inventor wants to work it in Germany, but finds that though his invention was not mentioned before, a broad patent, describing nothing practical and nothing new at all, has existed for more than five years, and covers his manufacture without disclosing it.

SHOULD THE PATENT OFFICE EXAMINE WITHOUT GUARANTEE?

The next question is whether the patent office should examine without guaranteeing the patent. Such an examination must be in a way irresponsible. The question is whether it is a benefit worth the expense. This system is carried to a high state of perfection in America. The examination in America is as searching as in Germany, but it is not so difficult, as the American examiners seem to be—if one may say so without disrespect to the Germans—more practical. In both countries they begin by quoting everything that by any kind of twisting up can be construed to relate to your invention.

This is generally supposed to be a way of finding out if you are really serious in wanting a patent. When you have fully explained the difference between things with no point of resemblance, a matter which is not always very easy, they send you things which are verbally like yours, but essentially different; at intervals they say your specification contains seventeen different inventions, needing seventeen separate applications, and that you are claiming things that are unclaimable and so on, and then the real work begins. When you eventually get as many of the seventeen patents as you think it expedient to invest in, you are probably very much better off than you would have been with a grant on your original specification, but the process is expensive to patentees and to the public.

THE STATE AS PATENT AGENT.

The broad question is whether the State should do the work of patent agents, whether the patentee likes it or not. When the examiner has power not only to advise, but to reject, very serious injustice may be done. There is a standard case of an early inventor being refused a patent for the ordinary transformer of to-day, because the examiner could not understand it at that time; but, of course, we only have one account of the matter, as the examiner cannot well give his. But the probability of such cases is great, without any fault on the part of the examiners. If the examiner has no power to reject, the examination is a great benefit to inventors. It is only a question of public policy whether the State ought to help inventors in this particular way.

THE NEW BILL.

The new Bill provides for examination as to novelty as far as past British specifications are concerned. On the one hand, this will be a great help to inventors. But this sort of search is very easy already, as the patent office publishes illustrated abridgments, which make this matter very easy. It would be a very good thing for an inventor who is ignorant of the history of his subject, to go through these abridgments himself. He would then know very much better how to draw up his specification. On the other hand, if the patent fees remain the same, it will be a benefit to industry to have the money spent on behalf of patentees, rather than absorbed by the Treasury. The great objection to the system is that people will think a patent is valid because it is allowed. The search is only as regards novelty, and even then it is incomplete. A prior publication is just as fatal in a foreign specification, or in the general literature of any country, provided a copy came to this country. The examination as to novelty will therefore be useless as a guarantee of novelty, though it may save many patentees who would otherwise re-patent old things. In addition to this want of novelty a patent may be bad on several other grounds. The specification may not describe a practical invention, or it may claim something which is not of a class that can be patented, that is to say which is not a patentable invention.

A SERIOUS DIFFICULTY.

One of the most serious difficulties as to novelty has not been dealt with at all, but it is a little difficult to explain. The question of whether a patent is valid or not is of no importance in itself; it is only important when there is a question of infringement. Now, almost every claim is capable of a broad or a narrow interpretation. If the patent is examined without any reference to a given alleged infringement, the patent may easily be passed as being for a novel invention on a narrow interpretation. Later on a rival makes something which is outside the narrow interpretation of the claims, but really takes what the inventor considers is his. He then says his patent covers his rival, as he is infringing his claims on their fair interpretation. According to present practice the patent is dealt with by the courts with the early history of the act on one side, and the alleged infringement on the other. If the claim is interpreted broadly enough to cover something that went before, the patent is void; if it is narrow enough not to cover what went before, there may be no infringement, in which case the patent may be useless though valid. It is thus really impossible to settle the question of novelty without having the alleged infringements before the umpires at the same time. The patent office examiners are therefore necessarily unable really to decide as to novelty, whether the Government guarantees the patents or not.

CONCLUSIONS.

To sum up, then, examination to determine novelty by the patent office, with power of rejection, is unsatisfactory in the case of skilled inventors, because they may have injustice done them owing to the examiners not being sufficiently skilled. Of course, the law courts may also be unintentionally unjust, but with the fuller investigation there undertaken, this is not so likely. If the examiners have power of rejection, no end of irreparable injustice may be done to all kinds of inventors by ill-advised rejection of really good applications. If the examination is thorough it is great waste of money, as thousands of patents have to be examined which are of no importance, because the inventions, even if apparently good, never come into use, or are superseded by others before there is any question of infringement. Finally, no examination can be conclusive when an invention is new. The inventor must be ahead of the examiner, or he would not be an inventor, and, apart from that, the examiner cannot form any true view of the invention, because a little time is necessary to give the distance necessary for true perspective.

Examination without guarantee of validity and without power of rejection, such as proposed in the new Bill, is an unnecessary expense to the patent office; but if it is carried out by reducing the surplus now paid to the Treasury, instead of by raising fees, it certainly would be a great benefit to inventors.

THE NEW ANCHOR LINER "COLUMBIA."

An account of the new Anchor liner *Columbia*, which has now successfully completed her maiden voyages across the Atlantic, and is one of the largest merchant vessels built on the Clyde.

A STEAMER which is not only a distinguished example of marine architecture in itself, but which also marks the occurrence of the jubilee of one of the world's historic "Lines," deserves more than passing notice. Such is the new twin-screw *Columbia*, of the Anchor Line, one of the latest products of the large shipbuilding and engineering establishment of D. and W. Henderson and Co., Limited, Meadowside, Glasgow. This yard is one of the oldest on the Clyde, being that in which early in the last century Messrs. Tod and Macgregor built many famous pioneers of the ocean trade. Though the site is the same, the equipment of the present establishment is very different from that of the old firm, who are regarded as the "fathers of iron shipbuilding," because they built the first iron sea-going vessel—the *Royal Sovereign*—some sixty-three years ago. Here also was built the first iron paddle steamer run by the P. and O. Company, the *Trafalgar*, with oscillating jet condensing engines of 370 i.h.p.—a figure that compares strangely enough with the 10,000 i.h.p. of the latest P. and O. liners.

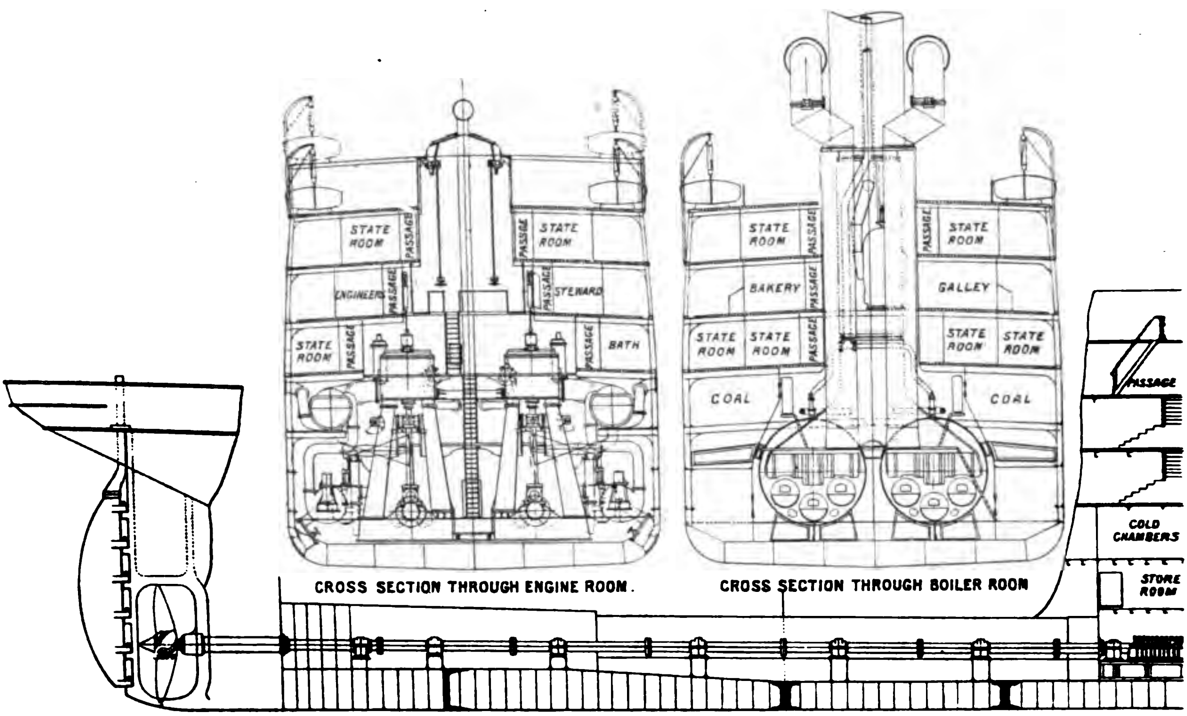
At Meadowside, too, Messrs. Tod and Macgregor, in 1850, built the *City of Glasgow*, famous as the pioneer iron screw steamer in the Atlantic trade. She was built for Glasgow owners, but was afterwards bought by William Inman and Co., Liverpool, and became the first vessel of the historic Inman Line. It is interesting to recall that she was 220 ft. in length, 32 ft. in breadth moulded, and 21 ft. in depth moulded. She was of 1,600 tons, and had overhead beam engines, jet condensing, of 310 h.p., with two cylinders 66 in. diameter and 60 in. stroke. About the same time the Anchor Line was founded by Messrs. Handyside and Henderson (now Henderson Brothers), Glasgow, who opened a direct trade between the Clyde and the Mediterranean with the little sailing vessel *Vasco da Gama*, of something under 200 tons. The Anchor flag now floats over a large fleet of up-to-date boats trading regularly between Glasgow and New York, the Mediterranean and the Clyde, the Mediterranean and North and South America, India and the Clyde, and between India and New York.

From the *City of Glasgow* of 1850 and the first iron Anchor Line steamer of 1852 to the new member of the fleet is a tremendous stride.

THE "COLUMBIA'S" ENGINES.

The *Columbia* is 500 ft. long, 56 ft. broad, and 36 ft. 6 in. deep. She has accommodation for 325 first-class passengers, 220 second-class, and 600 third-class or steerage. She carries a cargo of 5,350 tons on a draft of 25 ft., this being limited to enable her to navigate the River Clyde right up to Glasgow. She is driven by two sets of triple-expansion engines, of which we show a drawing. Each set has three cylinders, which are 31½, 51½, and 85 in. in diameter, respectively, with a piston stroke of 54 in.

The cylinders of each engine are rigidly bolted together, and stand on six massive cast iron columns. The front or inner columns are of rectangular section, and are divided at the bottom for the double purpose of giving fore and aft rigidity to the engines. By permitting the cranks to pass between the column feet, ample room is provided on the starting platform between the two engines. The back columns are of cylindrical section, with sufficient taper in their length to provide ample area at their bases. The sole plates are made in three pieces bolted together. They are of



CROSS SECTION THROUGH ENGINE ROOM.

CROSS SECTION THROUGH BOILER ROOM

hollow rectangular section, and have strong flanges at the bottom for fixing the engines to the top of the ballast tank. The crank shafts are made in three interchangeable parts, and are of the built type. Each part is carried on two bearings of extra length, and is lined with white metal; and, indeed, the bearings throughout the entire engines are made with extra large surfaces. The crosshead guide-plates on the columns are of hollow section, through which cold water circulation is provided.

AIR PUMPS.

The air pumps are on Edward's patent system, and are fixed to the back columns of the intermediate engines, from the crossheads of which they are driven by means of the usual levers. Attached to the air pump, one at either side, and driven by the same crosshead, are two bilge pumps.

CONDENSERS.

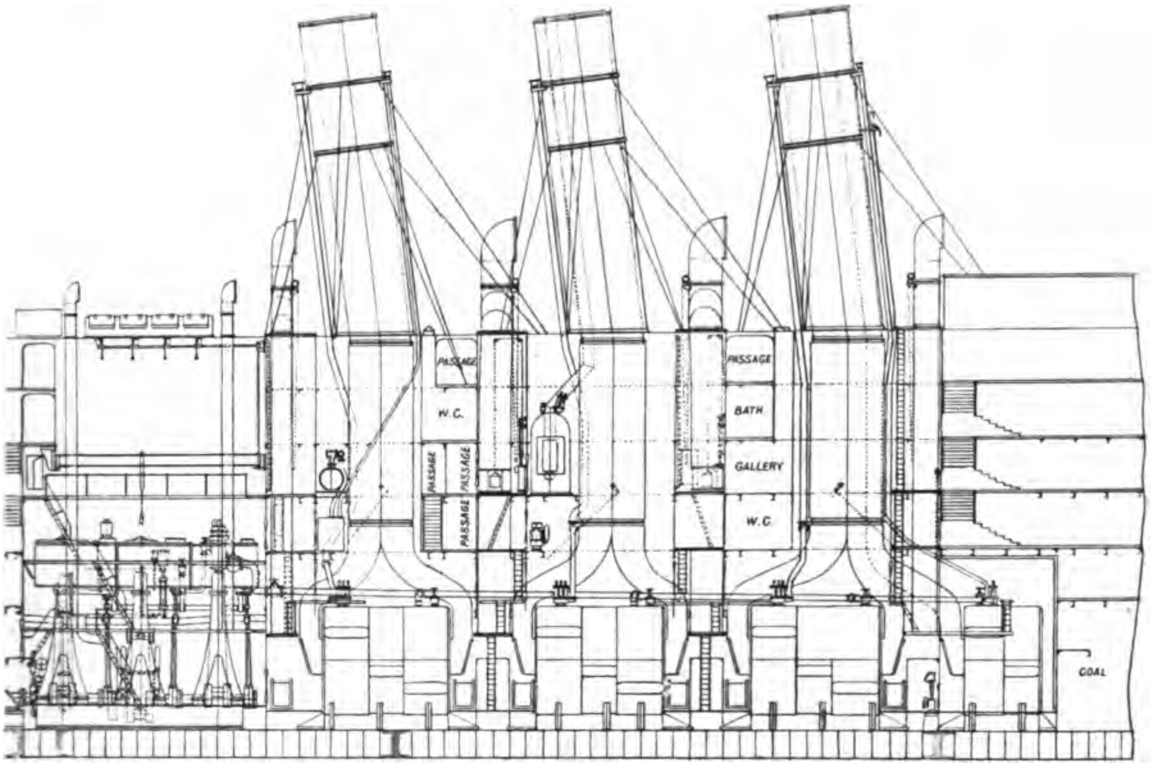
The condensers are carried on the lower deck beams close to the side of the ship, and quite separate from the main engine structure. The cold water circulation through them is supplied by two large centrifugal pumps driven by vertical steam engines, and placed on the level of the starting platform between the low-pressure engines and the ship's side, the diameter of the delivery pipe being 16 in.

FEED-WATER HEATERS.

There are no feed-pumps driven direct by the main engines, the whole of the water necessary for feeding the boilers being supplied by two pairs of Weir's feed-pumps of large capacity, either pair being sufficient to provide the entire feed-water required. To each set of pumps there is a pipe leading from the hot-well to a float-tank with automatic control valve; one pump taking the water from this float-tank passes it through an Alley and MacLellan's "Sentinel" feed-filter, and then into one of Weir's patent direct contact feed-heaters, from which the other pump draws the heated water and delivers it through the main line of feed-pipes to the boilers.

REVERSING GEAR.

For the rapid manipulation of the main engines in narrow waters a direct-acting, steam-reversing engine is provided, the cylinder of



which is attached to the back of the main cylinders immediately above the Wyper shaft, to which it is directly connected, and controlled by levers from the starting platform. The gear for regulating the main stop valves is placed close to the reversing levers. To permit of the accurate adjustment of the main stop valves, a screw gear worked by a hand-wheel is provided; but, in case of emergency, the steam can be instantly shut off the engine by simply pulling a lever.

THRUST BLOCKS.

At the after-end of the engine room is the thrust recess, which extends from side to side of the vessel. In it the thrust blocks are secured to steel seats built upon the ballast tank top. The thrust of each propeller is taken up by collars on the thrust shaft, bearing upon ten horse-shoe rings with large white metal bearing surface.

TUNNEL SHAFTING, ETC.

The tunnel shafting is made up in five convenient lengths, each carried on a pillow block with white metal lining. The propeller shafts, which are carried inside the skin of the ship right up to the stern frame, have, on this account, to be of extra length, and, to avoid corrosion where they are exposed to the salt water in the stern tubes, they are covered by gun-metal liners, extending from the fore end of the stern tube to the propeller bosses. The propeller bosses are of cast iron, and to each are secured, by studs and nuts, four bronze blades. The propellers are 17 ft. 9 in. in diameter.

In the thrust recess, between the two thrust blocks and immediately below the cold-storage chamber, is fitted a Hall's patent refrigerator of large capacity on the CO_2 principle.

ELECTRICAL MACHINERY.

Here also is placed the electrical machinery, of which there are two complete sets on opposite sides of the ship, either set being capable of lighting the whole ship, as well as of driving a large number of powerful electric fans, which are provided for ventilating purposes.

The dynamos are driven direct by vertical compound steam engines, the steam and exhaust pipes of which are independent of all other machinery.

PUMPS.

The pumping arrangements are on a very complete scale, and comprise two extra large duplex ballast pumps, one on either side of the engine-room. The ballast and bilge pipe connections being in duplicate, there is a complete system on either side of the vessel with connecting pipes at the after end of the engine-room. The two pumps may either work independently, or both may be connected to draw any one compartment of the vessel. By this arrangement it will be seen that in the event of a considerable leak occurring in any part of the ship there is ample provision for dealing with it.

In addition to these pumps there are two separate duplex pumps for pumping fresh water up to the service tank on the top of the engine casing for supplying the lavatories, galleys, pantries, etc. There is also a duplex pump for the supply of salt water to the sanitary tank, and another for fire purposes, in accordance with the requirements of the American authorities. All these pumps are by Messrs. Lamont, of Paisley.

BOILERS.

Steam is supplied by six large double-ended boilers and one single-ended boiler. These boilers are on the natural draft system, and are arranged in pairs, with a funnel to each pair, the forward funnel also acting for the single-ended boiler. The funnels are 107 ft. high, and have an outer casing throughout their entire length. There are in all thirty furnaces, giving a large heating and fire-grate area. The main steam pipes are led in duplicate, each engine having a separate pipe the whole length of the boiler space. A valve is fitted on the forward side of the forward engine-room bulkhead connecting these pipes for the purpose of equalising the steam pressure of the engines.

The placing of the boilers in pairs permits of the use of side bunkers throughout the entire boiler space. These bunkers are of sufficient capacity to steam the vessel across the Atlantic, and by this arrangement, the coal running naturally to the place at which it is required, the necessity of coal trimming is greatly reduced.

The boilers are of Siemens-Martin steel, and are fitted with thirty-nine Morrison's patent withdrawable furnaces. The total heating surface equals 30,000 square feet.

DECK MACHINERY, ETC.

For dealing with the large cargo the vessel is designed to carry, ten powerful steam winches of the builders' own special make are placed on deck. These have cylinders of 7-in. diameter and 12-in. stroke, and are provided with winding barrels of extra large diameter.

In addition to the large fresh-water tanks, a large distilling plant for condensing salt-water is provided, and a separate tubular boiler is fitted in the boiler casing abaft the centre funnel for supplying the necessary steam.

The steam steering-gear is fitted in a special house on the poop, and is worked from the bridge by a controlling shaft. It is of Caldwell and Co.'s make, and is of great power. The hand steering-gear is arranged in the same house, and a Cumming's patent oil cylinder rudder brake is also fitted.

SATISFACTORY TRIALS.

When on her trials on the Clyde the *Columbia* attained a speed of 18¼ knots loaded, which is considerably in excess of what she was required to do, and everything has worked with the most satisfactory smoothness on her subsequent maiden voyages both ways across the Atlantic.

The advantages gained by the progress that has been made in naval architecture since the *City of Rome* was built in 1881 are obvious on looking at the capacity of the two vessels as compared with the measurements, especially when it is remembered that the *Columbia* is an eight-day boat, leaving Glasgow on the Saturday afternoon and arriving at New York on the Monday morning.

COMPARISONS.

The *Columbia* is an exceptionally fine-looking vessel. She has a straight stem and elliptical stern, two schooner-rigged pole masts, and three tall funnels. She is divided into nine water-tight compartments. The passenger accommodation is distributed throughout six decks, so that the work of administration can be carried on with the greatest advantage to the passengers. The first-class rooms are specially luxurious, and the saloons are magnificently furnished and decorated, while the second-class state-rooms and saloons are almost as comfortable, though less finely decorated. In the third class there are more berths in each cabin, and there is little in the way of decoration, but the owners have provided all kinds of comforts in the matter of bedding, napery, and eating utensils, so that a voyage third-class in the *Columbia* has fewer terrors for the landsman than a voyage first-class in any Atlantic liner had a few years ago.

It is now over fifty years since the old *City of Glasgow* sailed on her maiden voyage from the Clyde, and a comparison of the dimensions and tonnages of the two steamers affords a fair indication of the growth and development of the Transatlantic trade since 1850 :—

	City of Glasgow.	*Columbia.*
Length ...	220 ft.	500 ft.
Breadth ...	32 ft.	56 ft.
Depth	21 ft.	36 ft.
Tonnage ...	1,600 tons	8,400 tons.
Engines ...	Overhead beam ...	Twin-screw.
Description ...	Jet condensing ...	Triple-expansion.

ANOTHER COMPARISON.

It is twenty years since the well-known *City of Rome* was taken over by the Anchor Line and placed on the Clyde and New York summer service. There is a marked difference in some respects between the *Columbia* and the *City of Rome*, so long associated with this service. The *City of Rome* was not built originally for the Clyde trade, but for the Liverpool trade; and while she has traded for many years from the Clyde, she has not been able to come much above Greenock except for dry-docking purposes. On comparing the two vessels, one notices in the *Columbia* the absence of the beautiful curved bow, with the handsome figure-head of Julius Cæsar and other externals, that went to cause the *City of Rome* to be regarded generally as the handsomest vessel engaged in the Atlantic trade. There are other striking contrasts between the *Columbia* and the *City of Rome*. The *Columbia* carries a larger cargo on a more moderate draft of water. The *City of Rome* has compound engines; the *Columbia* has triple expansion. The *City of Rome* works her boilers at a pressure of 85 lbs.; the *Columbia* works hers at a pressure of 180 lbs. The *City of Rome* has one propeller; the *Columbia* is a twin-screw. The coal consumption of the *Columbia* is very nearly one-half that of the *City of Rome*. The changes that have taken place in twenty years are all in the direction of economy and safety.

WORKSHOP PRACTICE

A RÉSUMÉ OF MACHINE TOOLS, CRANES, AND FOUNDRY MATTERS FOR THE MONTH.

A NEW LATHE.

THE appearance of a new automatic machine is always a fact of interest in the trade. A lathe of this class is now being manufactured by Mr. J. Parkinson, of Shipley. The following is a description of its principal movements, illustrated by outline drawings.

The machine, it should be observed, is not intended to compete with those that produce threads by screwing dies, but is designed for the production of those classes of screws which can be best, or most suitably cut in a screw-cutting lathe. It may not be supposed to be capable of turning out more work than can be performed by a skilled man, doing his best under the most favourable conditions, yet it will perform automatically and with absolute precision all that the best workman can do at his best continuously. Besides this, two or more machines can be operated by one attendant.

The principal points are these : The spindle rotates in one direction continuously. The various movements, save one, are driven through the lathe spindle, so that the sequence of motions of the mechanism is not affected by variations in the spindle speeds. The movements which are thus controlled are the setting in and withdrawing of the tool, and engaging the clasp nut with the lead screw. The exception is the running back of the saddle for starting another cut, which is performed at a uniform speed for all screws, and this is also made self-arresting, independently of any mechanism operated by the spindle. Threads of any section, right or left hand, are cut. The feed of the tool operates automatically, and is tripped also automatically after the desired depth of thread has been cut.

A valuable feature of this machine is that multiple threads are cut automatically, the tool catching the threads at the precise period required for two, or three threads, etc., and in but little more time than that required for single-thread screws. To those who know the difficulty of catching threads correctly, and the crude device of marking the change-wheels for the purpose, this alone is a very valuable provision. It is effected by a special mechanism,

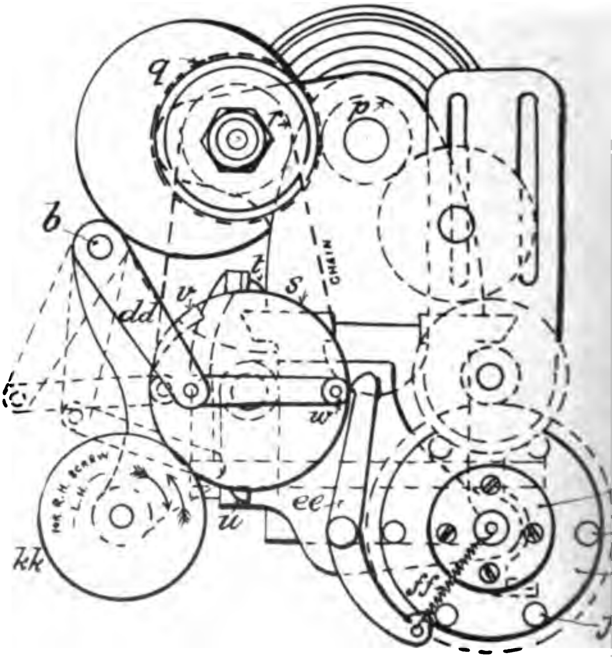


FIG. I.

the leading element in which is a loose ring attached to a driver-plate, and a pawl. The motion of the ring is arrested for half a revolution for two-threaded screws, and for a third of a revolution for three-threaded screws, and so on. The loose ring carries projections which strike the dog on the screw to be cut, and cause it to rotate. Notches are made in the driver-plate to correspond with the number of threads required.

The main operating mechanism of the lathe comprises a lead screw, and two shafts, one in front beneath the lead screw, and one at the back. The latter receives motion from the countershaft, and drives the shaft in front by a Renold chain—an example of the growing popularity of the chain drive, with its advantage of positive movement without chance of slip.

Figs. 1 and 2 show the lathe arranged for cutting right-hand threads. The adjustments being made, the shaft to be threaded is placed between the centres. The lathe, being started, commences to take the first cut. When the tool has reached the point for withdrawal, a projection on the saddle comes against an adjustable collar, *a* (fig. 2), on the controlling rod at the front of the bed. This operates mechanism which causes the shaft, *b*, at the rear and above the lathe bed to make a partial revolution, and thus by the crank, *c*, and a connecting link, *d*, to push the tool-slide away from the lathe centres. This movement of the tool-slide opens the clasp-nut, as will be noted on reference to figs. 3 and 4. At *e* (figs. 3 and 4) is shown the cam-shaft, the partial rotation of which closes or opens the halves of the clasp-nut, *f*, by means of the cam-plate, *g*. On the left hand end of the cam-shaft, *e*, is fixed a lever, *h* (fig. 3), on the boss of which is loosely fulcrumed a lever, *i* (figs. 2 and 3), so that both may move together, or the nut be opened by hand, if desired. Lever, *i*, is connected by link, *k* (figs. 2, 3, and 4), to the left side of the tool-slide; and thus the movement of the latter away from the lathe centres simultaneously causes the clasp-nut to open and release the screw. The movement of the tool-slide being continued a little further, causes the cam, *l* (fig. 4), which is connected with the lever, *i*, by the link, *m*, to slip a revolving bevel pinion, *n*, into gear with a wheel, *o* (figs. 2 and 4), and that drives a train of gearing in the apron, which, acting against the

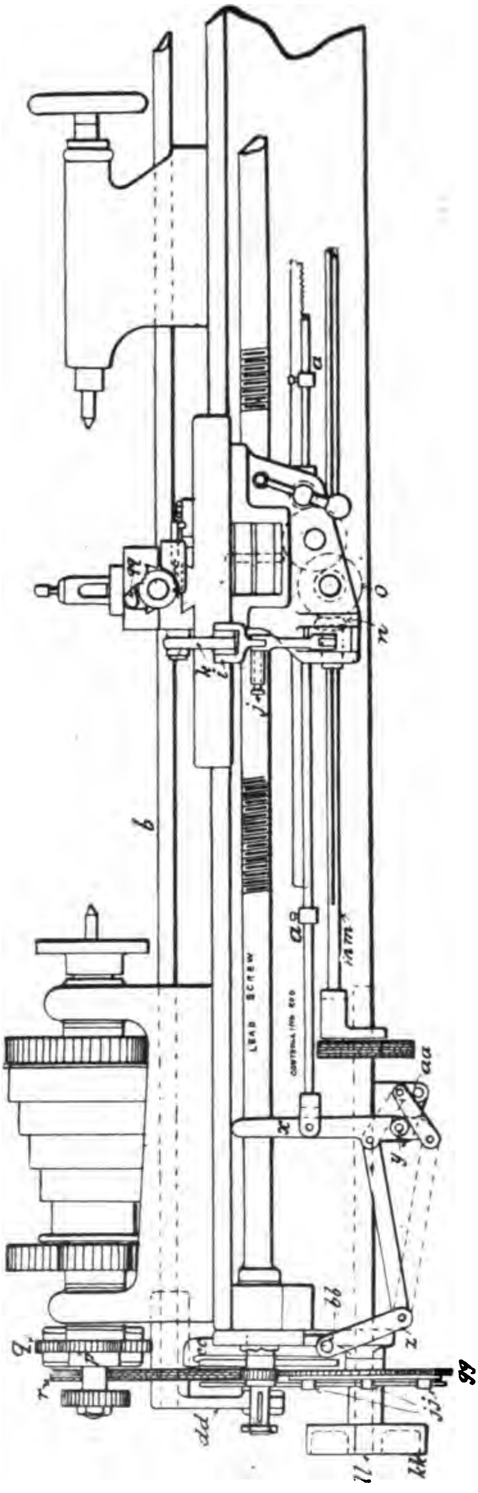


FIG. 2.

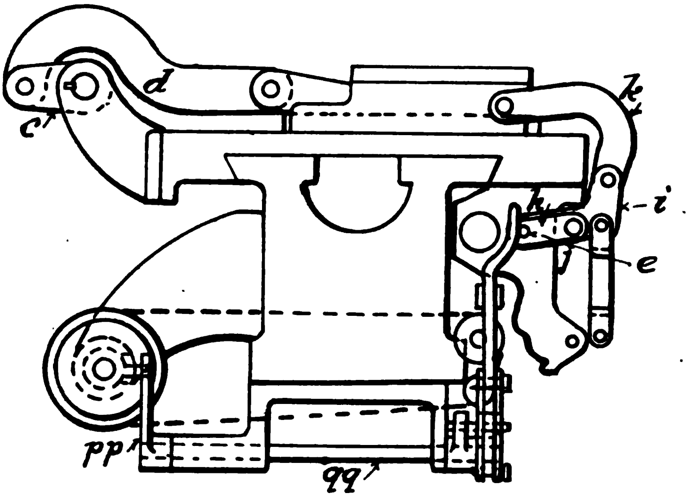


FIG. 3.

rack on the front of the bed, returns the saddle rapidly to the starting point. Just before reaching this position, however, the saddle strikes the collar, *a*, on the right hand side of the saddle, and again trips the mechanism for giving the reciprocating rotary motion to the shaft, *b*, which now pulls the tool slide towards the lathe centres. Simultaneously with this, the rotation of the shaft, *mm*, at the front of the bed, and which drives the sliding bevel pinion, *n*, is arrested, as will be explained presently, and thus the saddle comes to rest.

The next operation is to catch the thread, and to understand how this is effected we refer to fig. 1, which is an end view of the lathe. On the end of the spindle there is the driving change-gear, which actuates the driven wheel on the lead screw, through the usual train of gearing, carried on a quadrant plate. The latter is omitted from fig. 2 for the sake of clearness. Behind the change-gear on the spindle is another spur-gear, *p*, driving a spur-gear, *q*, which runs between friction discs; attached to one of these there is a chain wheel, *r*, which drives, by means of a Renold silent chain, the wheel, *s*. This wheel has on each side a disc, the inner one having two projections or catches, *t*, *u*, diametrically opposite, and the outer one a notch, *v*. A stud or crank pin, *w*, projecting through the outer disc, by a link connection actuates the lever, *dd*, on the end of shaft, *b*.

Turning again to fig. 2, the controlling rod is seen connected at the left with a lever, *x*, fulcrumed on the stud, *y*. This in turn is connected by links to the levers, *z* and *aa*. The lever, *z*, is keyed on a rocking shaft, to the outer end of which is keyed the lever, *cc*, which has a projection or catch, overhanging the inner disc of the wheel, *s*. Thus, the lateral movement of the controlling rod causes the lever, *cc*, to come within the path followed by one of the catches, *t* and *u*, as the wheel, *s*, rotates, and to arrest the rotation, the slipping of the friction discs against the wheel, *q*, allowing this to take place. These catches are so placed that as the lever, *cc*, is moved from the path of the catch, *t*, it comes into that of the catch, *u*. It is thus impossible for the wheel, *s*, to make more than half a revolution at each release.

Thus the movement for withdrawing the tool is effected, first by the saddle moving the controlling rod to the left, which causes the lever, *cc*, to release the catch, *t*, and allows the wheel to make half a revolution, or, until the catch, *u*, strikes the lever, *cc*. This movement throws the lever, *dd*, on shaft, *b*, to the outer of the two positions shown by the dotted lines, at the same time giving the shaft, *b*, its extreme movement in one direction, withdrawing the tool slide, releasing the lead screw, and returning the saddle towards its original position, just before reaching which, as already shown, the controlling rod is moved to the right, the catch, *u*, released and the shaft, *b*, rotated a portion of its movement, sufficient to slide the bevel pinion, *n*, out of gear with the wheel, *o*, fig. 2. This time however the wheel, *s*, is only allowed to make about one-sixth of a revolution, the notch, *v*, being caught by the hook on the double-ended lever, *ee*, which is held against the periphery of the disc by the spring, *ff*. The lever, *dd*, is thus arrested in the intermediate position, shown by dotted lines, and with the tool, lead screw, and bevel pinion disengaged.

Immediately below the lead screw, and driven by a small pinion upon it, is a spur-gear, *gg*, so arranged that it makes only one revolution to twelve of the lead screw. Clamped to this gear by the plate, *hh*, is a disc, *ii*, carrying twelve studs, *jj* (six only are shown), which come in turn against the inclined ends of the lever, *ee*, and cause it to trip out of the notch, *v*, and release the wheel, *s*, which is then free to make the half revolution required to draw in the tool slide, and engage the lead screw.

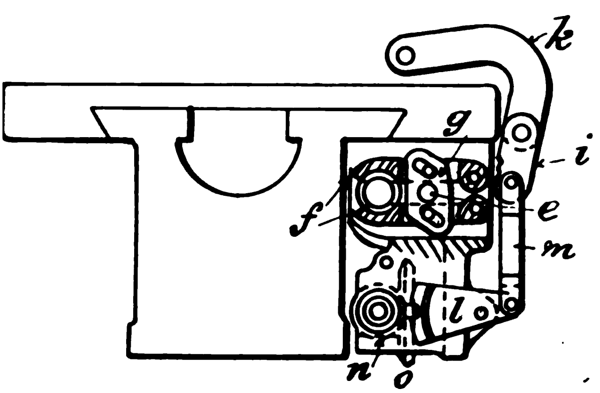


FIG. 4.

It will now readily be seen that the exact point at which the threads of the lead screw are engaged, is determined by the position of the studs on the disc, *ii*, and, as already indicated, these may be readily set to trip the lever at any desired point. The lead screw has two threads per inch, and it follows that in cases where the threads to be cut coincide with the lead screw, every half-inch engagement may take place correctly at each revolution of the latter, and all the twelve studs may remain in, each one corresponding to one revolution of the screw; but if the threads to be cut only coincide with every other thread of the screw, then six of the studs must be taken out; if every third, then only four opposite studs remain; if every fourth thread, three studs equally spaced are retained. In this way, for any pitch that coincides with the pitch of the lead screw, anywhere within six inches, the thread is caught correctly.

The motion for running back the saddle is driven by a separate belt (crossed for right-hand screw) from the countershaft, on to the pulley, *kk* (figs. 1 and 2), mounted on the shaft, *ll*, which transmits the rotary motion through a Renold chain to the shaft, *mm*, at the front of the lathe. The chain wheel, *nn*, driven by the shaft, *ll*, is not fixed directly thereto, but is driven by clutch projections on the disc, *oo*, which slides on a key, being moved in or out of contact with the corresponding projections of the wheel, *nn*, by the lever, *pp* (figs. 3 and 5), which is fixed to a shaft, *qq*, carried in a bracket beneath the lathe bed. To the front end of the shaft, *qq*, the lever, *aa*, is fixed, which, as already stated is connected as shown by a link to the lever, *x*. The movement of the saddle when returning to its original position, thus not only actuates the lever, *cc*, and releases the wheel, *s*, but, immediately after doing so, it throws the clutch, *oo*, out of gear, and automatically arrests its return movement. The lever, *pp*, is acted upon by a spring, not shown, which brings the clutch projections of the wheel, *nn*, and disc, *oo* (fig. 5), into contact, so that the shaft, *mm*, again commences to rotate, just before the withdrawal of the tool.

For cutting left-hand screws, the direction of rotation of the lead screw is changed, the pulley, *kk*, is driven by an open belt, and the points of connection with the lever, *x*, of the links which connect the two levers, *aa*, are transposed, as shown by dotted lines.

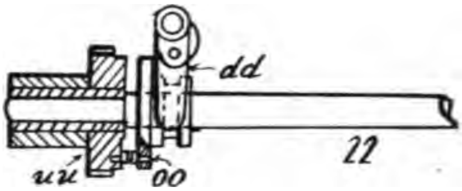


FIG. 5.

The rapidity of the work done by this lathe may be judged from these facts: A single-threaded screw in iron, 1 in. diameter, with right and left hand threads, each 6½ in. long, was cut in ten minutes; a double square-threaded screw in iron, 1 in. diameter, 16 in. long, was cut in nineteen minutes; a very deep square-threaded screw in steel, 1⅛ in. diameter, and 2 ft. 3 in. long, was cut in forty minutes.

MACHINE TOOLS.

The shops of the Cincinnati Milling Machine Co., whose recent designs are illustrated in this month's article on "Milling Machines," have a system of compressed air laid throughout for the purpose of cleaning chips from work in progress. All machine tools and vice benches are supplied with branches, and each branch terminates in a nozzle, having a valve closed with a spring, opened by the pressure of the thumb. Among the advantages gained besides that of cleanliness, is higher rates of feed to cutters, which could not be obtained if the work were clogged with chips. It is noteworthy that another firm applied an air suction to a slab miller some years ago, the chips being sucked up, instead of being blown about to the detriment of bearings and slides.

Messrs. Ward and Co., of Birmingham, have brought out a new double-cutting planing machine. A single tool is used having two cutting edges, one at back and one at front, the end being concave to give clearance. Both edges are ground at one operation, to ensure uniformity. The swinging of the tool box to bring the tool edges alternately into action includes side and under cutting, as well as horizontal, effected by two pivots, vertical and horizontal respectively, and both are regulated by the feed mechanism.

A good deal of ingenuity has been expended in designing combination machines, once more popular than they are at present, for the modern tendency is in the direction of specialising and limiting the operations of machine tools. But the universal tools always afford an interesting study. One of these has been designed for the use of Navy artificiers, and made by the Process and Engineering Co., of Farringdon Road, E.C. It is a self-acting, sliding, and surfacing lathe, swinging 60 in. and 14 in. between centres. It is also both a horizontal and vertical milling machine, and a profiling machine, a shaper, and slotter, and a boring machine.

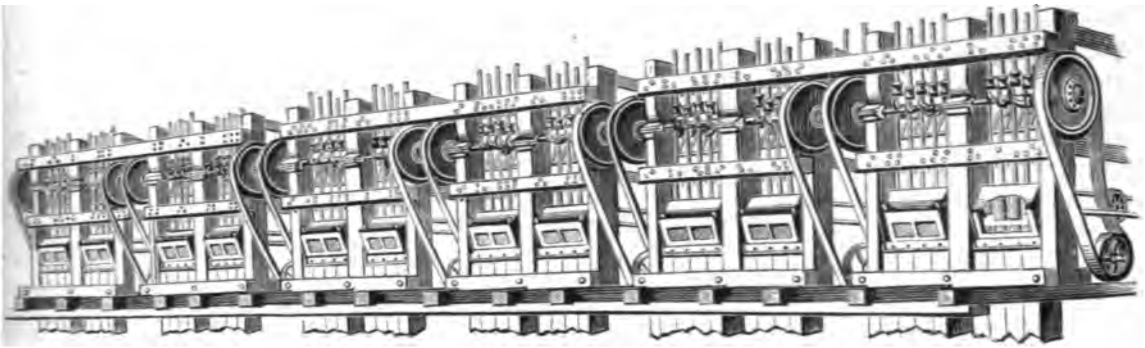
NEED FOR A FOUNDRYMEN'S ASSOCIATION.

Though a good deal has been accomplished recently in remodelling our foundries, there are still far too many—the majority, in fact—which are destitute of modern appliances, and lacking an intelligent class of men. There is nothing here like the American Foundrymen's Association, which is composed of leading men in the trade, proprietors, and foundry managers, who meet in convention once a year—as the members of the Institution of Mechanical Engineers do here—at some industrial centre, and read and discuss papers and visit establishments. The American Foundrymen's Association now numbers 314 members, with an income for the last year of $2,353. The papers read are practical, written by men from the shops, and discussed from the standpoint of the practical moulder, in plain, forceful language. Technical knowledge is much in evidence, but only that which bears directly on foundry matters, chiefly the chemistry of cast iron, the chemistry of the cupola, and so on. Such an association of managers makes its impress on the men, and sharpens the friendly rivalry of the shops.

A familiar sight at the core bench is the straightening of crooked wires pulled out of the cores by the fettlers. This is a boy's job, getting the kinks and bends out with hammer blows. A time-saver recently invented is an American machine for performing this work. The wires are drawn through grooves in rolls made to suit wires of various gauges, the grooves being corrugated to bite the wires. The lower roll is stationary, the upper one is movable against the downward pressure of coiled springs.

GERMAN CRANES.

In our last issue we alluded to the German activity in the manufacture of machine tools. We now have occasion to mention the crane industry, the particular incident which justifies it being the fact that a German crane is being built for Messrs. Wm. Beardmore and Co., right in the centre of the Scotch crane industry. It will be an electric crane of 200 tons power. We do not know whether this is a question of price, or of time of delivery, or what else, but we have for three or four years past anticipated that the rivalry of American and German crane makers will prove as serious as that of the machine tool makers has. Our insular position narrows the observations of the average man, but those who are closely in touch with crane work know that German cranes have many good points, that German engineers were first in the field in the successful electric driving of cranes, and that they are still more advanced in that field than we are. Moreover, they have made a speciality of certain types which are now in high favour, chief among which is the portal, or gantry crane. They are well represented in London, and probably will be more so as business develops.



60-STAMP GOLD MILL.

MODERN PRACTICE IN MILLING AND AMALGAMATING.

BY

EDGAR SMART, A.M.I.C.E.

THE variations of milling practice in different parts of the world present some remarkable contrasts. A mining expert making a tour of the globe, and travelling either eastward or westward from the eastern side of Australia, say from the Charters Towers Goldfield as a starting point, will find that the amount of ore crushed in stamp mills, reckoned per stamp per day, gradually increases until he reaches the goldfields of the Transvaal. The following figures, which represent approximately the stamp duty obtained in several mining countries, will fortify the above statement:—

	Per stamp per day.
1. Charters Towers, Queensland ...	about 1½ tons.
2. New South Wales	2 to 2½ tons.
3. Victoria	2½ to 3 tons.
4. Western Australia	3½ to 5 tons.
5. Witwatersrand	5 to 6½ tons.
6. United States	4 to 5 tons.
7. New Zealand	1¾ to 2¼ tons.

The reasons underlying the remarkable differences which are observable in the above figures will be set forth in this article, at least in part; and afterwards by discussing, somewhat in detail, the more important of the several divisions of the subject, it will be shown how and why the high stamp duty is obtained in the Johannesburg mills.

LOW RATE AT CHARTERS TOWERS.

As regards the first-named district, Charters Towers, the following explanation of the low duty was given to the writer by a man intimately connected with mining in the district. The majority of the miners hold strongly to the opinion that a high rate of crushing necessarily reduces the percentage of gold caught, and, as will be seen later on, this may be true if the higher stamp duty is achieved by means which are unsuitable for the ore which is to be crushed. As the batteries on this field are largely run as customs mills for public crushing at a fixed charge per ton, while the gold won is taken by the owners of the ore, the work has to be carried on in accordance with the wishes of the customers, and for this reason the speed of running is limited to 60 drops per minute. Of course, under these circumstances it is not surprising to find that the methods now in use show little trace of the advances which have been made in other countries.

EMULATION LACKING IN N.S.W.

In New South Wales up to the present time the gold mines have been, generally speaking, worked on a small scale, a thirty-head mill being considered to be a fairly large undertaking.

This is because the gold is found either in shoots or patches of limited extent, although sometimes of great value. Consequently, the amount of development work is large in relation to the ore bodies opened up, and it is therefore impossible in most cases to keep a large mill continuously running. The batteries also are scattered widely apart, and as there is no regular official publication of the results obtained, there is an absence of that beneficial spirit of emulation among millmen which is found in crowded mining districts where they can see each other's work and know each other's results.

IN VICTORIA.

In the colony of Victoria there are a number of mines in the outlying districts to which the above remarks also apply. On the larger goldfields, such as Bendigo and Ballarat, the gold is usually very coarse and easily caught, so that the chief difficulties occur and the most skill is required in the mining department. Therefore the management is naturally entrusted to an intelligent, practical miner, and the milling does not receive the special expert attention which is required when dealing with very fine gold. The batteries are almost always built in the colony, and as the results are satisfactory to both makers and purchasers, it is perhaps scarcely wise for an outsider to offer any adverse criticism. It has to be remembered also in comparing the output with that obtained in other countries, that practically the whole of the material crushed consists of fairly hard quartz. Still, it seems likely that by adopting a heavier type of stamp, and by substituting woven wire screens for punched plates, fewer stamps would be required for an equal amount of ore.

In the Kalgoorlie district of Western Australia the conditions are so unique that a comparison of results with other places can scarcely be made. On the one hand the gold is so finely divided that the output has been limited by the absolute necessity for very fine crushing, while on the other hand the comparative softness of the ore has, of course, tended to increase the stamp duty.

LOW STAMP DUTY IN NEW ZEALAND.

As regards New Zealand, the following reasons sufficiently explain the very low stamp duty on the principal goldfield at the present time, namely, the Hauraki district. In the first place, the ore is exceptionally tough ; secondly, the gold is finely divided, and, therefore, fine crushing is required ; and, thirdly, as the whole of it is treated by cyanide, it is either crushed dry or with very limited quantities of water, so that the pulp is very thick.

SOUTH AFRICA OUTSTRIPS THE UNITED STATES.

As America was certainly the home of first-class milling practice, which was transplanted to the Witwatersrand largely by American engineers, it appears strange, at first sight, that South Africa should have outstripped the United States. The whole reason for this lies in the extent and in the consistency and regularity of the gold-bearing reefs, which enabled development to be carried on with a precision and certainty which have never been possible in any other country. With few exceptions, the mills were backed up, and, so to speak, oppressed by large and constantly increasing ore reserves in the mines, and as depth was attained the ore became harder, so that, unless the mills had kept pace with the mines, the total output would have gradually decreased. Here, then, were all the conditions necessary for that practical form of evolution known as the survival of the fittest, and the struggle applied both to mills and millmen. Mills which in some parts of the world would have been considered as models of perfection, were ruthlessly, but correctly, sacrificed and superseded by designs more adequate to the task imposed upon them.

The above brief glance at the principal conditions which modify the milling practice on a few of the more important goldfields of the world, shows that no fair and adequate criticism is possible without carefully considering, in detail, a number of conditions which affect the final result in each particular case. Those points which bear upon the quantity of material crushed will first be dealt with, and afterwards those connected with the recovery of the gold.

THE NATURE OF THE ORE.

From a crushing point of view ores may be roughly classified in the following manner :—

Soft, such as the silicates of alumina and magnesia.

Friable, such as the upper and completely oxidised portions of heavily mineralised lodes.

Hard and brittle, as the semi-translucent quartz met with so often in all parts of the world.

Hard and tough, as chalcedonic quartz, quartzite, and the like.

Hardness can be defined and measured on the ordinary scale used by mineralogists. Toughness is a more elusive quality; but anyone accustomed to break up samples of many kinds of ore can achieve both definition and measurement with a hand hammer. A tough ore is one that rebounds after a blow, and is reduced in size by *attrition* rather than by *cracking*, except under a very massive blow.

SCREENS.

Over the greater part of Australia punched plates are largely used, but in South Africa woven wire screens are almost universally employed. The great advantage of the latter is that for equal sized holes they have a greater discharge area than the plates, but their disadvantage is the necessity for more frequent renewal owing to breakage. This, however, is a small matter compared with their greater capacity, and as only the lower part of the screen is really effective for discharge, the cost of renewals can be reduced to a minimum by using shallow screens, or, as is sometimes done, by turning the screen upside down when the lower part is worn.

The size of the holes in the screen depends not only upon the condition in which the gold occurs in the ore, but also upon the methods of extraction which are to follow the crushing process. For instance, when amalgamation only is to be employed in recovering the gold, it is necessary to break the gangue to such a fineness that the particles of gold are absolutely *detached* from the stone. But when the amalgamation process is to be followed by any method of bringing the gold into solution, it is sufficient to *expose* the said particles without necessarily detaching them. Hence on the Rand, where cyanide treatment is invariably applied to the mill tailings, there has been a steady tendency towards coarser screens, always with the one object to increase the output of the mill, and thus lessen the cost of crushing per ton, so far as this can be done without lessening the total extraction. In the early days, 1,600-mesh screens were the rule, then 900-mesh. Now 700- or 600-mesh is common, and even 400-mesh is sometimes used. The increase in output caused by the change from 900- to 700-mesh in that district amounted to about 10 per cent. And the tailings residues to-day are certainly lower than they were nine or ten years ago, but that, of course, is due to improvements in the cyaniding. Still, allowing for this improvement, the results conclusively show that even with very finely divided gold very coarse crushing is not incompatible with good extraction.

SPEED OF STAMPS.

It is clear that there is an absolute limit to the speed at which gravitation stamps can be run, which is determined by natural laws; for if the drop be not completed before the cam gets in the way, the stamp tappet will fall on the cam instead of the head upon the ore. If the stamp be considered theoretically as a freely falling body, the time required for, say, a 9-in. drop will be 0·215 second. Allowing an equal time for the lift, and no loss of time between the two, the maximum speed attainable in theory with a 9-in. drop will be 139½ drops per minute. But the stamp does not fall with perfect freedom, because there is the friction of the guide blocks to be taken into account, neither would it be possible practically to run with no interval of time between the completion of one drop and the commencement of the next lift.

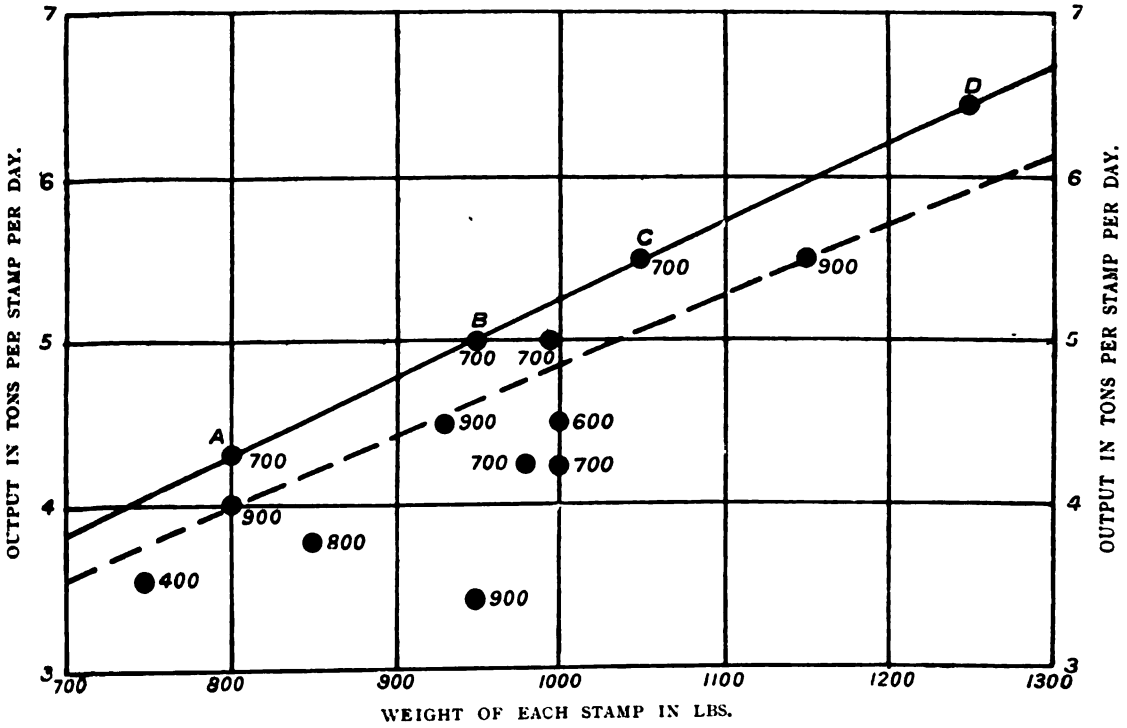
Therefore it is evident that nothing approaching the result figured out above can be expected in practice; and the speed of about 95 drops per minute with a fall of between 8 in. and 9 in. now attained is not likely to be exceeded with stamps of the ordinary gravitation type. Rapid running stamps have been designed, provided with springs which are compressed during the lift of the stamp stem, and when released by the cam these springs accelerate the speed at which the stamp falls, and thereby allow it to be run at a greater number of drops per minute. Also by substituting parallel motion links in place of the present guide blocks, some increase of speed might be obtained, but as the simplicity of the machine is diminished by the addition of either springs or links, no real practical advantage is likely to result from such modifications in the design. Accepting, therefore, a speed of 95 drops at 9 in., or 100 drops at 6 in., as the practical limits of speed allowed by the mechanical conditions of the problem, it seems to be clear from the milling point of view that all stamps should be run at this speed, or as near to it as their condition of repair will allow; for to run at less than the maximum speed is, so far as crushing is concerned, almost exactly equivalent in its results to stopping the mill altogether during a portion of each day. Whether any improvement in the amalgamation is effected by slow running is a question to be dealt with later on.

WEIGHT OF STAMPS.

Having reached the practical limit of speed, the next direction in which the millman will naturally turn to enlarge the output from his battery is towards heavier stamps. On the Witwatersrand the gradual but continual increase in the weight of the stamps has shown conclusively that on the class of ore there prevalent each increment of weight up to the present limit of 1,250 lbs. has resulted in an increase of output. It may be objected to this view that the use of screens of coarser mesh has contributed to the result, and this is, no doubt, true to some extent, but a reference to the points lettered A, B, and C in the diagram below will show the result of increased weight in three cases where the screens were of equal mesh. It has to be remembered also that the pyritic ore now being crushed with the heavy stamps is very much harder than the oxidised ore that was dealt with some years ago, when the lighter stamps were in vogue. While this shows that the increase of stamping power has been actually greater than is indicated by the figures plotted on the diagram or tabulated below, it must not be taken for granted that an equal advantage can be obtained in the same way when crushing soft or friable ores, neither is it safe to assume that there is no limit to the increase of output which is obtainable in this manner.

In order to exhibit actual results in a form in which they may be readily compared, the annexed diagram has been plotted from a number

DIAGRAM SHOWING BETWEEN WEIGHT OF STAMPS AND THEIR OUTPUT.



of published returns * relating to various mines at Johannesburg. The weights of the stamps are plotted as abscissæ and the corresponding outputs as ordinates.

The outputs were all adjusted to a uniform speed of 95 drops per minute, and the height of drop only varied from 7½ in. to 8½ in. The size of the screen mesh, where known, is indicated by the numbers placed alongside the black circles. As might have been expected, there is a considerable variation even in cases where the conditions are apparently similar, but the most striking and unexpected circumstance is that the four highest results, A, B, C, and D, fall into an absolutely straight line. Considering that the irregularities exhibited are probably due to imperfect feeding and other matters which would all tend to diminish the output, it seems quite reasonable to conclude that this straight line fairly represents the maximum output (for that class of ore) which can be maintained in actual work on a large scale and over a long period with 700-mesh screens. The numbers in the following tables were obtained by measurement from the same diagram plotted on squared paper. The dotted line shows the probable maximum output obtainable with 900-mesh screens :—

TABLE I.

Weight of stamp in lbs.	Tons crushed per stamp per day.		Weight of stamp in lbs.	Tons crushed per stamp per day.	
	700-mesh.	900-mesh.		700-mesh.	900-mesh.
700	3·85	3·69	1,000	5·27	4·85
750	4·08	3.80	1,050	5·50	5·06
800	4·32	4·01	1,100	5·74	5·27
850	4·55	4·22	1,150	5·97	5·48
900	4·79	4·43	1,200	6·21	5·69
950	5·02	4·64	1,250	6·44	5·90

Output for Witwatersrand banket according to weight of stamps. At 95 drops per minute, about 8-in. drop, and 4-in. to 6-in. height of discharge.

An inspection of the above table shows that an increase of 100 lbs. in the weight of the stamp has about the same effect upon the output as the change from 900 to 700-mesh. For instance, taking the 1,050 lbs. stamp, the change of screens makes a difference of 0·44 ton per day, while an increase of weight to 1,150 lbs. makes a difference of 0·42 ton with the finer screen, and of 0·47 ton with the coarser screen.

FEEDING.

This is a most important matter as regards the output of a battery. The essential principle of proper feeding may be expressed paradoxically by saying that the more slowly the material is put in the more quickly it comes out, or, in other words, by keeping only a very thin layer of ore on the dies the stone is more readily broken. A little consideration makes this quite clear, for if the stamp falls on a piece of rock which itself lies directly upon the die, the piece receives the whole force of the impact. On the other hand, if the piece receiving the blow is embedded among a number of other pieces which form a thick layer over the die, the downward motion is gradually instead of suddenly arrested, as it squeezes together the layer of loose pieces, and only a portion of the effect is available to crack them. And, of course, the effective height of fall is also less when there is a lot of ore above the dies. The writer had these truths forcibly impressed upon him many years ago, when running a small hand-fed battery with a Boer feeder. This man soon discovered that by throwing in a lot of stuff at one time, he could then sit down for half an hour while the choked-up battery gradually cleared itself. The obvious and successful remedy was the substitution of a less intelligent but more industrious Kaffir.

Now, it is evident that as the feed should be kept low, it must of necessity be very regular,

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* Some of the necessary data were taken from "The Gold Mines of the Rand," Hatch and Chalmers, 1895, p. 202.

in order to prevent actual contact at any time between the shoes and the dies. In this respect hand-feeding properly done is quite perfect and superior to automatic feeding, but the amount of attention required for the former, and the consequent cost, turn the balance in favour of automatic feeders, which also give excellent results. That is to say, the feeding is so regular that it can be adjusted to give a very low feed without causing undue breakages. Consequently in all mills, large and small, where a high stamp duty and low costs are required, automatic feeders are provided.

The output of a battery also depends to some extent upon the size to which the ore is broken before it reaches the boxes. It is evident that previous breaking reduces the work required of the stamps; but as it takes fewer blows to break up the larger pieces than it does to crush the whole to the size of the screen holes, it is also clear that there must be a practical limit somewhere beyond which the preliminary breaking should not go. Mr. T. K. Rose[*] puts this limit at ½ in. cubes, but 2 in. to 2½ in. is far more common practice where rock breakers are used. There seems little to choose between the two types of rock breaker principally in use, namely the reciprocating jaw breaker and the rotary machine, the principal point being that the apparatus of either type should be one that is turned out by experienced makers. In Australia the Blake machine seems to be the favourite, in Johannesburg the Blake or the Gates is generally used, and in America the Gates and the Dodge breakers are largely employed.

DISCHARGE OF PULP.

The discharge from the mortar boxes is effected to a small extent by the continual flow of water through the boxes, but the principal agent in the ejection of the crushed rock is the splashing caused by the fall of the stamps. As each stamp descends, it splashes the pulp in all directions and to a limited height according to the weight and drop. As the only part of the splash which assists the discharge is the part which strikes the screen, it is evident that if the lower edge of the screen is very much higher than the tops of the dies, so that a large portion of the splashed pulp strikes the solid front of the mortar box below the screen, the conditions are unfavourable for a rapid discharge. When, therefore, the main object is to keep the ore in the boxes for a considerable time with a view to inside amalgamation, deep mortar boxes with a high discharge are used. Before the development of cyaniding and pyritic smelting, this was the usual and successful practice in districts where amalgamation had to be relied upon alone for the extraction of ores containing minerals which tended to sicken the quicksilver and retard amalgamation. Nowadays, however, the practice is rather to crush such ores coarsely and rapidly, and to rely upon other methods, such as concentration followed by smelting, or direct cyaniding, for the recovery of that part of the gold which is not readily amalgamated. Therefore low discharge is one of the features of modern milling in most countries where proper attention has been given to the subject. On the Rand very low discharge is the rule, even down to 2½ in. in some cases. The wear and tear of the screens is increased because they are battered by a larger proportion of coarse pieces when they are low, and therefore it is not advisable to place them lower than is necessary to discharge the ore just as fast as it is crushed to the requisite size. So far as one may judge from a comparison of results which are, however, affected by other variable conditions, it appears that there is nothing gained by reducing the height below the following figures for hard quartz ore or banket:—

With 400-mesh screens	...	2½ in.
„ 700 „ „	...	4 „
„ 900 „ „	...	5 „

CONTINUITY OF WORK.

Having secured the maximum efficiency of the stamps during the time they are working, it is also equally important that the work shall not be impeded by accidental stoppages. A series of interruptions caused by breakages or the like costs much more than a complete stoppage for repairs at regular and suitable times, because in the first case all the mill labour has to be paid for during the time the battery is idle, but only a small part of it in the second case. The following are the principal conditions by which is secured that continuity of operations which is characteristic of the best milling practice at the present day.

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[*] "The Metallurgy of Gold," 1896, p. 101.

1. Sound construction in every detail when the mill is erected, and a liberal allowance of steam power.
2. Constant maintenance of battery and engine in good repair.
3. The provision of convenient means of access to every part of the machinery.
4. An overhead travelling hoist for the rapid replacement of wearing parts.
5. A sufficient and efficient staff.
6. Plenty of storage capacity in the ore bins to provide against irregularity in the delivery from the mine.

The first three of these conditions really have to do with the design and construction of mills, which is beyond the scope of the present article; but the last two may be briefly discussed.

STAFF.

In mills of good design with full equipment, including automatic feeders and well-arranged with respect to accessibility, the following number of men should be sufficient for the various sizes, where white labour is employed:—

For 10 stamps—one man and one boy per shift.

For 25 stamps—one amalgamator and one engine-driver for each shift.

For 50 stamps—one amalgamator, one assistant ditto, one engine-driver, one stoker per shift.

For mills of the sizes given above there is not sufficient work to keep a millman or mechanic continually employed, but for larger mills the regular staff should include two fitters and a carpenter, who may work their shifts at suitable times as required. In addition to these a 100-stamp battery should have one amalgamator with two assistants, one engine driver, and one stoker. In some cases, according to the situation and arrangement of the plant, it is necessary to employ separate attendants for some parts of the machinery, such as crushers or elevators. It is always desirable that the men who handle the amalgam or the plates should have no dirty or greasy work to do, and this is possible in large mills, where special greasers can be employed. In Johannesburg, where Kaffir labour is apparently cheap, there is no difficulty about extra labour of this kind, but in small mills where native labour is not available, the amalgamators have to do all the work around the mill, and every facility should be provided to induce cleanliness in dealing with the mercury and amalgam.

ORE BINS.

As the considerations which govern the storage capacity of a mill illustrate the method of deciding many points of metallurgical practice, it may be worth while to go into the question somewhat in detail at the risk of being tedious. If the bins are too small, any irregularity in the output of the mine immediately interrupts the crushing. If too large, there is a loss consisting of interest and redemption on the extra cost of constructing them, and interest on the cost of raising the extra ore lying in the bins. Of course, no account need be taken of the gold in the extra ore, because if it were not in the mill it would remain equally unavailable in the mine. Take the case of a 50-stamp mill crushing 300 tons per day, and assume the following costs: For stoping, raising and tramming ore, say, 12s. per ton, which is equal to £180 for each 300 tons. The interest on this at 5 per cent. per annum amounts to 0·021 pence per ton crushed per annum. Cost of extra bin capacity for 300 tons, say, £100. The interest on this with its redemption in, say, ten years, amounts to 0·027 pence per ton. The additional storage, therefore, means an increase of 0·048 pence per ton to the cost of crushing. Now against this may be placed the loss due to one day's stoppage of the mill. Assuming that the total yield per ton of ore is 9 dwts., the output is lessened by £540, on which the interest amounts to 0·062 pence per ton on the yearly output of, say, 105,000 tons. Then there is a partial loss of wages on all the surface work, and the extra cost of stopping and re-starting the various operations, which may be put down at not less than £30, and which works out at 0·008 pence per ton. The result is that stopping the mill for a single day costs 0·07 pence per ton, while the provision of an extra day's storage costs only 0·048 pence per ton. If the shortage of ore occurs several times in a year, the balance in favour of a large bin capacity is still more pronounced. The saving of one day's interest on the cost of the battery might also fairly be added to the credit side of the account, and it is not surprising, therefore, to find that much larger bins are provided in modern mills than was customary a few years ago. Formerly, one day's supply was considered sufficient, whereas now as much as three days' supply is provided for.

WEAR AND TEAR.

Some interesting experiments on the actual wear of shoes and dies of various materials were made at the mill of the Robinson Company in Johannesburg many years ago,[*] which are, however, still of value, as there has been practically no advance in this direction since that time. The best results showed that the shoes diminished in weight at the rate of 4½ ozs., and the dies at 2½ ozs. per ton of ore crushed, or 7 ozs. altogether. In 1900, at the Haile mine[†], the wear of shoes and dies together was 0·5 lb. per ton, which is almost identical with the best Robinson figure. But as there is at present no unanimity of opinion as to the best material, the average of the Robinson Company's experiments, as given below, will more nearly represent the wear in general practice :—

Average weight of shoe when put in	171 lbs.
" " taken out	44 lbs.
Actual loss of weight in working	127 lbs.

Tons crushed, 379.

Therefore the average wear of the shoe is 0·335 lb. per ton. But there is also the 44 lbs. of material discarded, which has also to be debited to the cost of crushing, and which works out at 0·116 lb. per ton of ore. The following figures relate to the dies :—

Average weight of die when put in	119 lbs.
" " taken out	51 lbs.
Loss by attrition in working	68 lbs.

Tons crushed, 347.

Therefore the loss by attrition = 0·147 lb. and by waste 0·196 lb.

Adding these four figures together, the average total loss of shoes and dies is 0·794 lb. of steel for each ton of ore crushed.

The usual materials may be placed in the following order as regards durability, the most durable being placed first: Chrome steel, manganese steel, Bessemer steel, forged steel, iron.

If the matter were merely one of the cost of material it could be easily settled by comparing the total wear multiplied by the cost per lb. of each material, but the time occupied in replacing the worn-out shoes and dies has also to be taken into account, and for a maximum output the most durable material would be chosen, unless, of course, its price should be prohibitive. There are also a number of other parts in a battery which require renewal, the chief of these being stems, tappets, cams, and bearings, which, however, do not amount to much per ton of ore.

EXPENDITURE OF POWER.

In driving a mill the greater part of the work is done in lifting the dead weight of the stamps, and this can be readily calculated for any given case. Thus for each 1,000 lbs. stamp at 90 drops per minute, with an 8-in. drop, 1·82 h.p. is required theoretically. But the friction of guide blocks, cams and bearings adds generally about 10·63 h.p. to this calculated quantity, so that the real amount required is 2·45 h.p. per stamp. Similarly a 1,250 lbs. stamp with an 8-in. fall at 95 drops per minute will actually require about 3¼ h.p. per stamp. The total power required for a 100-head mill of the heaviest type now in use may be summed up as follows :—

Stamps, 100 at 3¼ h.p.	325 h.p.
Rock breakers, say 25 tons per hour ...	30 "
Sundries, say	15 "
Total power required... ...	370 h.p.

This approximate estimate shows the importance of the fuel consumption, and explains why with the erection of large and heavy mills so much more attention is given to the type of engine selected. Whereas formerly a single-cylinder high pressure engine was considered good enough, the practice on the Rand at the present time is to provide compound condensing engines, with surface condensers. And while coal remains at 20s. per ton there is every inducement to engineers to introduce all apparatus which may tend to economy in the consumption of fuel. In Australia for many years firewood was so plentiful that little attention was paid to this matter, but lately the supply of firewood has become exhausted in the immediate neighbourhood of the older goldfields, and it has to be carried constantly increasing distances, so that the price is steadily rising, and the question of economical engines will probably receive more attention from mining men.

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[*] *South African Mining Journal*, 31st December, 1892.

[†] Mineral Industry, 1900.

ORE SORTING.

So far all the points considered have related either to increase of tonnage or decrease of cost, but anything tending to enlarge the output of gold or increase the profit is equally important, and therefore the question of ore sorting essentially belongs to the milling problem.

The process of selection, of course, begins in the mine, and is of necessity carried out in every mine to a greater or less extent. If the sampling and assaying are systematically carried on during development, the average value of each block of ore opened up should be fairly well ascertained by the time it is prepared for stoping. And, as a matter of course, everything which will not pay for raising and treating should be left behind, and the payable portions only should be taken out, so far as this is consistent with the methods of working. But when the broken ore is brought to the surface, there is generally some country rock mixed with it, and very often it contains many lumps of ore which, if taken separately, will not pay for the subsequent processes. The problem, then, to be considered is whether it is profitable to sort out the less valuable pieces before milling, and to what extent this should be done.

For the purpose of this discussion, the bulk of the broken ore may be divided into three classes in the following manner:—

1. Ore which is undoubtedly payable and about which nothing further need be said.
2. Ore which will pay for all current charges, such as costs of labour and material actually incurred in its treatment, but not for the whole of the fixed charges, such as redemption, etc.
3. Ore which will only pay for part of the actual treatment costs.

The inclusion of the second class in the supply to the mill is correct, because if it contributes anything towards the fixed charges it relieves the rest of the material from part of such charges, and causes a real increase in the total profit from the mine on its whole life; although, of course, a larger temporary profit might be made by its exclusion. And this line of reasoning appears to offer a basis for genuine distinction between what is called "picking the eyes out of a mine" and the legitimate selection and sorting of the ore—namely, that anything which is done to increase the profits for a time at the expense of net total profit comes within the meaning of the phrase above quoted, and is essentially bad policy. In estimating the total profit of a mine, due consideration must be given, not only to the interest on capital sunk in development and other matters, but also to the earning power of the gold itself when extracted. On the Witwatersrand, where the mines have to such a great extent been controlled by men of great financial ability, these considerations have been fully weighed, and the result, as shown below in Table II., is that surface-sorting has been very properly adopted in many mines in that district.

To return from this digression to the third class of ore given above, the main point which determines its inclusion or rejection is whether the actual loss in current expenses caused by its treatment is less or more than the cost of picking it out.

To make this quite clear, the following example is given, in which the figures represent the actual costs on the Rand of the various items concerned in the problem :—

	s.	d.
Rock-breaking, per ton... ...	0	4
Transport to mill	0	4
Milling	2	9
Cyaniding (all material) ...	2	10
	6	3
Fixed charges per ton	1	6
	7	9

Cost of sorting per ton of ore rejected, 2s. 6d.

Then, according to the reasoning already given, class I. will include all ore which yields more than 7s. 9d. per ton. Allowing for a total extraction of 88 per cent. from the best ore, everything over the value of 2·2 dwts. per ton belongs to the first class.

Calculating in the same way, but allowing only 80 per cent. extraction on lower grade material, all ore over 1·95 dwts. belongs to the second class.

Dealing now with the third, or doubtful, class, and allowing only 70 per cent. extraction from this lowest grade, the limiting value between inclusion and rejection may be arrived at thus :—

If treated, it costs	...	6s. 3d. per ton.
If wasted, it costs	...	2s. 6d. „

Therefore net cost of treatment is 3s. 9d.

As ore containing 1·34 dwts. will at 70 per cent. extraction give a yield of 3s. 9d. per ton, it follows that it is profitable to sort out all material below this value and to retain all above it, under the conditions which have been assumed.

To avoid misconception, it is necessary to point out that in the selection of ore in the mine before stoping a much higher grade than this would be left in place, because then the cost of raising and tramming would be included in the current working costs. The above figures only relate to surface sorting.

THE PRACTICE OF SORTING.

Turning now from the economic to the practical side of the matter, it is evident that sorting can only be introduced when there is some readily visible difference between the richer and poorer pieces of ore. It is especially easy when the gold is so intimately associated with some definite mineral in the ore that the value of the stone can be directly inferred from the quantity of that particular mineral which is present in each piece. On the Rand the banket conglomerate is the valuable material, and this can be easily distinguished from pieces of the country rock when the ore is washed on the sorting table.

The sorting is usually effected by passing the ore as raised from the mine on to a travelling belt or a revolving circular table, where a jet of water plays upon it. The sorters stand alongside the table, and pick the pieces of waste rock from the continual stream of mixed material which is carried slowly past them. The ore remaining upon the belt or table, after it has passed the sorters, is delivered to the rock breakers. A table, 25 ft. in diameter, with an annular sorting rim not exceeding 2 ft. 3 in. in width, is suitable when the sorters stand at the outside edge only, as is the case when the apparatus is driven from a central vertical shaft. This size is sufficient for sorting out about 20 per cent. of waste from, say, 700 tons of ore daily. The cost with Kaffir labour and white supervision amounts to about fourpence per ton of ore mined, so that if 20 per cent. of the total is sent to waste, the cost works out at fivepence per ton calculated on the quantity milled, or at 1s. 8d. reckoned on the tonnage sent to the waste dump. At 16 per cent. of waste the figures will approximate to 4·76 pence and 2s. 1d. respectively. The degree to which sorting has been applied may be realised from the following table, which has been compiled partly from the annual reports of Mining Companies, and partly from data in the condensed reports published in the *South African Mining Journal* :—

Name of Mine.	Period over which average is taken.	Year.	Tons mined and hoisted.	Tons after sorting.	Percentage sent to waste dump.
Ferreira...	3 months ...	1896	42,141	28,911	31·39
Meyer and Charlton	10 ,, ...	1897	111,099	89,753	12·14
New Heriot	7 ,, ...	1897	86,171	64,290	25·51
Ferreira...	6 ,, ...	1897	92,022	62,419	32·17
Crown Reef	12 ,, ...	1897-8	221,543	185,179	16·41
,, ...	12 ,, ...	1898-9	239,413	202,456	15·53
Lancaster West	5 ,, ...	1899	34,770	31,730	8·74
Robinson	9½ ,, ...	1899	223,008	165,035	26·00

TABLE II.—Showing some variations with regard to the sorting of ore before milling, as practised on the Witwatersrand goldfields.

As some of the Johannesburg companies have not adopted sorting, the total variation is from 32 per cent. to zero ; and doubtless some of the differences are due to the varying thicknesses of the reef and to the value of the ore. But it would be interesting to know how much of the variation is to be attributed to these causes, how much to differences in the relation between working costs and fixed charges, and also how much is due to the personal opinions of the several managers upon the question of sorting.

(*To be continued.*)

STANDING CHARGES.

BY

CLAUDE W. HILL, Assoc.M.Inst.C.E., M.I.E.E.

A PROPERLY arranged system of manufacturing and trading accounts, in addition to showing net profits, should serve two purposes; first, it should provide figures upon which a correct judgment can be formed, in preparing estimates, as to the amount to be added to the bare cost of material and labour to cover standing charges; and, secondly, it should, by giving the items in detail, show in what direction economy may be sought.

Standing charges may be conveniently divided into two classes—External Expenditure, such as advertising, railway carriage, coal, etc., for which invoices are received from outside, and which are comparatively simple to deal with; and Internal Expenditure, such as repairs and maintenance, shop expenses, pattern work, etc., which are rather more difficult to deal with.

EXTERNAL EXPENDITURE.

Each morning, when the letters are opened, the invoices are placed in heaps and handed to the invoice clerk. He stamps each with the stamp (Form No. 29), and gives it a consecutive number, which he, at the same time, enters in the Invoice Guard Book (Form No. 74).

INVOICE GUARD BOOK.
Form No. 74.

No.	Invoice.	General Purchases.	Advts., Circulars, and Catalogues.	Carriage.	Rents, Rates, and Taxes.	Books and Stationery.	Law and Patent Fees.	Insurance.	Unbooked Material.	Capital Account.	Repairs Account.			Totals.
	Brought forward......													
	Carried forward......													

STAMP FOR INVOICES.
Form No 29

No...

Received by...

Prices Correct...

Casting Out...

Our Order No..

Passed by...

Capital Account...

R. and M. Account.....................................

Stock Ledger..

Com. Ledger..

Packing Dept...

The invoices then go to the storekeeper to be checked against the goods, and on their return to the invoice clerk are folded up and pasted in the Guard Book, their amounts being entered in the columns to which they relate. Thus, if the goods are for manufacturing purposes, they will be entered under "General Purchases" or "Unbooked Material," while, if they form an item of standing charge, they will be entered under that particular heading.

It will be noted also that columns are provided for the amount of goods purchased for capital account and for repairs and maintenance.

If it is considered inadvisable that all the items of standing charge should be known to the general staff, those which it is thought desirable to keep private, such as law charges, patent royalties, etc., may be posted in a separate private Guard Book.

In addition to items for which invoices are received, cash payments have frequently to be made, and for these columns should be provided in the Cash Book similar to those in the Guard Book. The Guard Book and Cash Book columns are totalled every month and carried forward to Standing Charges (Form No. 79).

INTERNAL EXPENDITURE.

For the determination of internal expenditure standing order numbers which have the prefix S.H., to distinguish them, are given to each part of the buildings, such as S.H. 1, foundations and walls; S.H. 2, drains and sanitary work; S.H. 3, roofs, and so on; and to the plant, as S.H. 21, power plant; S.H. 22, line shafts, pulleys and bearings; S.H. 23, belting, and so on.

There are also standing numbers for labouring: such as S.H. 101, sweeping and cleaning up shop; S.H. 102, assisting fitters; S.H. 103, working crane.

All material supplied out of stores, and all labour executed on buildings or plant, is booked in the usual way in the Stores Day Books and Time Cards respectively, and from them to the Buildings Account or Plant Account Cards (Form No. 68).

For each order number two accounts are kept, one being headed "Capital Account," and the other "Repairs and Maintenance"; and, in order that they may be distinguished easily, they are kept on cards of different colour—say blue for capital account, and buff for repairs.

In order to prevent reckless expenditure, each foreman should enter on a weekly

BUILDINGS, PLANT, &c., ACCOUNT.
Form No. 68.
Capital account on blue cards.
Repairs account on buff cards.
Totals of repairs on white cards.

Date.	Description.	External Purchases.				Internal Expenditure.						
		G.B.	£	s.	d.	P.C	Material.			Labour.		
							£	s.	d.	£	s.	d.

Requisition Note (Form No. 53) whatever additions, repairs, or renewals he requires for the buildings or plant under his charge.

When authorising the different items, the manager marks on the note whether the cost shall be booked to capital or repairs, being guided by the principle that expenditure which increases dividend-earning capacity shall be booked to capital and all other to repairs.

PLANT REQUISITION NOTE.

Form No. 53.

This Requisition Note is for additions, renewals, and repairs to the buildings and shop plant, whether the same are to be obtained from outside firms or made in the shop. This note to be made out every Wednesday and handed into the Chief Engineer's Office on Thursday morning.

All additions, repairs, and renewals must be entered on the Requisition Note. Urgent repairs must be executed at once, but all others must wait the authorisation of the Manager.

For.	Description.	Addition, Repair, or Renewal.	Quantity.	Probable Cost.	From.	Authorised.			Remarks.
						Order No.	Date.	Signed.	

In addition to the items posted from the Stores Day Book and Time Cards, the items from the "capital" and "repairs" columns in the Guard Book and Cash Book must also be posted to the buildings and plant accounts.

Each month the buildings and plant repairs are carried forward into a summary, the rulings of which are the same as Form No. 68, and which may be kept at the back end of the card drawer, being distinguished from the others by being white. The totals from these again are posted to the Standing Charges Account (Form No. 79).

The "general labouring" items are posted from the Time Cards into "General Labouring," the columns of which are totalled and carried forward into standing charges each month.

MANUFACTURING ACCOUNTS.

(NOT PUBLISHED.)

MATERIALS.

BOOKED MATERIALS—	
Stock at last stock-taking, including cost of material in finished stores and work in hand	£35,000
General Purchases	65,000
	£100,000
Present Stock, including cost of material in finished stores and work in hand	£32,000
	£68,000

STANDING CHARGES.

Form No. 79.

Ref.	Description.	January.						February.						March.					
		Items.			Totals.			Items.			Totals.			Items.			Totals.		
		£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.

Cost as per Prime Cost Books. Materials booked to Prime Cost ..			£65,000	
Less cost of materials taken from finished stock ..			5,000	
			£60,000	
Materials booked to finished stock			£7,000	
Materials from "General Purchases"† used for shop work—				
	Capital.	Repairs.		
Buildings	£	£40	40	
Plant	102	265	367	
*Patterns	250	100	356	
Packing cases	130	40	180	£67,943
	£472	£451	*Discrepancy	£57
Unbooked Materials				
Last stock-taking			£3,500	
Purchases			4,000	
			£7,500	
Present Stock			2,200	
Material used			£5,300	
Booked Material			£60,000	
Unbooked			5 300	
Discrepancy			57	
			£65,357	

In estimating, the percentage to be added to net cost of material = $\left(\frac{65,357}{60,000} - 1\right) \times 100 = 9$ per cent.

Labour (see forward) booked on customers' orders	£37,500
Standing charges as taken from published profit and loss account	38 000
	£75,500

In estimating, the percentage to be added to net cost of labour = $\left(\frac{75,500}{37,500} - 1\right) \times 100 = 101\cdot3$ per cent.

LABOUR.

Finished Stock Account—	
Cost of labour on finished stock at last stock-taking, including stock orders in hand	£7,000
Cost of labour on stock orders completed (from Prime Cost Books)	10,000
	£17,000
Cost of labour on present stock, including stock orders in hand	£6,500
Booked out	£10,500

Labour Account—			
Total labour on customers' orders			£37,500
Less cost of labour on work taken from finished stock..			10,500
			£27,000
Labour booked on stock orders . ..			10,000
Labour booked to orders in hand			4,000
Labour on shop work—			
	Capital.	Repairs.	
Buildings	£—	£10	19
Plant	75	170	251
Patterns	600	212	812
Packing cases	250	93	343
	£925	£500	
General labouring			2 500
			£44,025

This total agrees with the totals of the Wage Book and Cash Book

Repairs and Maintenance Account—	Material.	Labour
	£	£
Buildings. Direct purchases (from Guard Book)	80	—
Buildings. Shop work (from Prime Costs)	40	10
Plant Direct purchases	100	—
" Shop work	265	170
Patterns. Direct purchases	—	—
" Shop work..	106	212
Packing cases. Direct purchases	—	—
" " Shop work	40	93
	£700	£500

Material	£700
Labour	500
	£1,200

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* For explanation of "discrepancy" see article on "Prime Cost" in July issue.

† For explanation of "unbooked material" see article on "Prime Cost" in July issue.

GROSS PROFIT.

Expenditure.	£	Income.	£
Labour booked to customers' orders completed	37,500	Sales	158,857
Material ditto ..	65,357		
Gross profit	50,000		
	£158,857		£158,857

PROFIT AND LOSS ACCOUNT.

(FOR PUBLICATION.)

Expenditure.	£	Income.	£
Salaries of office and works, interest on loans, rates, rents, taxes, &c. (all taken from their various books and specified in detail)	20,800	Gross Manufacturing Profits	56,000
Repairs and maintenance	1,200	(Any other income, such as pupils' fees, rents from sub-tenants, &c., would be entered here.)	
Depreciation of buildings and plant	8,000		
Net profit	17,000		
	£56,000		£56,000

PATTERNS.

The writer considers that the best way to deal with patterns is to book all new patterns to capital account, writing off depreciation at each stock-taking to an extent depending on the class of work being done.

For each size of machine (or engine, etc., as the case may be) manufactured, a separate pattern account is kept, the ruling of which is the same as Form No. 68, two accounts being kept on cards of different colours, one for capital and the other for repairs and renewals, the system being the same as for buildings and shop plant.

Packing case accounts are arranged in the same way as the pattern account, and the cases are also numbered so that they can be followed up and identified.

STANDING CHARGES, FORM NO. 79.

Reverting now to this book we see that all the items which go to make up the standing charges for one year appear on one page, and can be totalled in two directions.

Horizontally we obtain the total of each item for the year, and vertically we obtain the total of the items for each month.

PROFIT AND LOSS ACCOUNT.

In cases where the accounts have to be published, such as in that of limited companies, it is usual, in order to avoid giving away information which would be valuable to competitors, to divide this account into a "Manufacturing Account," which is kept private, and a "Profit and Loss Account," which is published.

The annexed example shows how the percentages to be added to prime cost of materials and labour are ascertained.

ENGINEERING EDUCATION IN AMERICA.

BY

FRANK HIX FAYANT.

This Article, by the Special Correspondent of a leading New York journal, sets forth from an American standpoint the advantages of a Transatlantic training for engineering students, and shows how this is to be obtained.

IF one needed proof of the value of American training for English engineering students, it would be scarcely necessary to cross the Atlantic for the purpose. But to examine the system and the methods employed it is desirable to visit some of the Eastern industrial towns of America—Pittsburg, Altoona, Cincinnati, Cleveland, Philadelphia, Schenectady or Wilmington,—where, because of their alertness of mind, young Englishmen are especially welcome.

In the works of a great American Electric Company, recently, there were four hundred graduates of the leading engineering schools of the world; many of them, the sons of rich men, working for 1.25 dols. a day. Nearly a score of foreign countries were represented among these student workers, the British contingent being the largest. Young men from Birmingham, Manchester, Leeds, Newcastle, Sheffield and other industrial towns were there, absorbing Western ideas to be brought back to engineering establishments at home. American manufacturers welcome these young men from rival commercial nations, because they believe that, while they are training brains for foreign competitors, they are widening American markets by the diffusion of American ideas.

HOW TO START.

The young Englishman who wants the best engineering education should go to America when he leaves the public school, and enter the Freshman class of one of the engineering universities—Sibley College, Cornell University, Ithaca, New York; the Massachusetts Institute of Technology, Boston; the University of Michigan, Ann Arbor; Lehigh University, South Bethlehem, Pennsylvania; the School of Mines, Columbia University, New York; Rensselaer Polytechnic Institute, Troy, New York; the Sheffield Scientific School, Yale University, New Haven, Connecticut. The register of any of these institutions can be had by writing the college secretary. Among the four hundred American colleges there are scores of institutions giving more or less attention to engineering, but the seven named provide the most complete courses. Cornell and the Massachusetts Institute of Technology take first rank. The director of Sibley College is Dr. Robert H. Thurston, the Nestor of the higher engineering education in America, and one of the world's leading authorities on the steam engine. "I am from Cornell" is the open sesame to many great engineering establishments.

PRELIMINARY QUALIFICATIONS.

The "entrance requirements" of the engineering schools have reached a higher plane year by year. No young man should think of choosing an engineering career who is not fond of mathematics. To enter a freshman class in engineering the candidate must have, as part of his secondary school training, a thorough knowledge of arithmetic, elementary algebra, plane and solid geometry, plane and spherical trigonometry, and higher algebra. Too much emphasis cannot be laid on the necessity for original work in mathematical problems. The best possible preparation is furnished by English text books. No inadequately prepared student can hope to follow the pace set in American engineering schools. Dr. Thurston finds that two-thirds of the Sibley Freshmen fail to complete the four years' course. Specimen entrance examination papers may be had from any of the institutions named. It would be advisable for an English candidate to take the June examinations and then spend the summer in a university summer school preparing for the September examinations.

UNDERGRADUATE'S COURSE.

The thoroughness of the American training may be judged from an outline of the work at Cornell. The undergraduate spends four years in lecture-room, laboratory, and shop work, studying for the degree of mechanical engineer or electrical engineer, and in his upper-class years he has opportunity to specialise in the particular department he chooses for his life work—steam engineering, electrical engineering, mining engineering, railway mechanical engineering, or marine engineering. Dr. Thurston strongly urges young men to gain a broad general education before specialising. In the course of a recent interview Dr. Thurston remarked that no young man should attempt to enter the profession of engineering because it seemed to him the current fad. "To succeed, he must have natural talent for construction, natural ability in the fields of mathematical and physical science, and that vigour, pluck, endurance, and good sense, without which no man can succeed in any profession, old or new. He must have a practical as well as a theoretical imaginative side; he will need a good general education, and a very complete and specialised professional training, including the arts as well as the sciences of his department. Above all else, if he would attain the highest success, he must be a strong man, an honest man, and a gentleman. A real engineer's novitiate in the professional school, in the office, and in the workshop furnishes the highest possible guarantee of success."

PRACTICAL INSTRUCTION.

Throughout the four years' course the engineering student works nine hours a week in the college shops, where he receives practical instruction in the use of tools and in the fundamental arts which form the basis of his afterwork in mechanical or electrical engineering. In the wood-working shop he acquires skill in the construction of patterns. These he takes later into the foundry, where he becomes adept at moulding and making castings from iron and brass. His work in the smithy, the next step in shopwork, is not complete until he has made for himself a set of tools to be used in the machine shop. Finally, in the machine shop he fashions complete machines with his own tools from castings he has made from his own patterns. While Cornell is in no sense a "technical school," and "manual training" is foreign to its aim, some of the practical work done by the students would do credit to the best engineering works. Specimens of the students' work noticed by the writer included various machine tools, a duplex pump, the pioneer "straight-line engine," and a 100-horse-power triple-expansion engine.

LABORATORY WORK.

Supplementing the instruction given in classroom and lecture-room by several score professors and assistants is the highly important work of investigation and scientific research carried on in the finely equipped laboratories. The work of the electrical engineering laboratory is known to every electrician in America, while the mechanical laboratories, possessing an equipment unequalled in any engineering works, are of inestimable value to the engineering profession. They include special laboratories for the investigation of the following subjects :—

(*a*) Strength of materials;
(*b*) Hydraulics and hydraulic motors;
(*c*) Friction and lubrification;
(*d*) Transmission of power, dynamometers;
(*e*) Steam engines, hot air and gas engines;
(*f*) Air-compressing machinery, rock-drills;
(*g*) Heating and ventilating machinery;
(*h*) Elevators and mining machinery.

The new hydraulic laboratory, built against the rock wall of Fall Creek gorge, below the Sibley shops, is the most elaborately equipped building of its kind in the world. Similarly, the laboratory of strength of materials is known to the engineering profession all over America. It is equipped with a large number of the newest testing machines, ranging in capacity from 300,000 lbs. This laboratory is constantly made use of by manufacturers who desire to have materials tested, and the students benefit greatly by this practical work. Cornell students, especially seniors and graduates, are frequently asked to make tests of power and electric stations, street railways, and new machines, and no student can take his degree without having done original research of an exhaustive nature in some specialised field. Dr. Thurston tells the students that their engineering careers begin in the university, and that no student should expect to receive the University's degree who is not an engineer by experience as well as by training at the end of his course.

AN IDEAL CURRICULUM.

Dr. Thurston has several times been called by the Government as an expert on engineering education. His views on the subject of engineering curriculum are interesting and to the point:—

> Educational work has no proper place in the curriculum of the professional school. That should be done, and completely, in advance. Such literature and such languages, only, fall into the scheme, properly and naturally, as contribute to the engineer's technical and professional stores. A complete line of advanced mathematics, pure and applied; as much of the physical science of the time as constitutes a part of the fundamental basis of his professional training; instruction and training by practice in the art of the draughtsman and in the mechanical and industrial arts; applications of mathematics and the sciences in machine design, and in the computation of the probable efficiency and performance of the machines and apparatus of manufactures; and, finally, the methods of determination, by experiment, with every scientific aid, of the value of such machinery in its actual use, and still higher applications of scientific method to the prosecution of original investigations of engineering problems and of research, looking to the acquirement of new and useful facts and principles in science and in every department of his work—these are the purposes and the proper field of the professional school of the engineer.

DOLLAR-A-DAY POSITIONS DURING VACATIONS.

Undergraduates are encouraged, during the long vacations, to put on working-men's garb and take dollar-a-day positions as machinists' helpers in engineering works. It is no uncommon thing to see the sons of railway presidents, ironmasters or shipbuilders, at work, begrimed with dirt and grease, alongside of moulders or machinists. The young men who are to be the future American captains of industry thus acquire practical training, and at the same time come closer into touch with the common soldiers of the industrial army.

INSPECTION TOURS.

The inspection tours to industrial centres are likewise a feature of the practical instruction. This spring, at Cornell, the writer saw forty engineering students leave for Western Pennsylvania, under the guidance of the head of the School of Railway Mechanical Engineering, who gave a continuous field lecture. The embryo engineers inspected the great electric power plant at Niagara Falls, and its dependent industries; the blast furnaces, open-hearth furnaces, Bessemer steel works, iron and steel rolling mills, and the electric, air-brake, and engine works of the Pittsburg region; the railway repair shops, and locomotive shops of Dunkirk and Altoona; railway roadbed construction in the mountains; and a bituminous coal mine near the Horseshoe Curve. Managers and works superintendents were subjected to a fire of questions.

STUDENTS' COST OF LIVING.

Students at the American universities live either in college houses or in private homes in the university towns. The cost of living varies with the individual tastes of the student. Rooms and board may be had for from one to two pounds a week; text-books and materials cost from five to ten pounds a year; the charge for tuition varies, in different universities, from nine to forty pounds a year, the Massachusetts Institute of Technology and the Rensselaer Polytechnic Institute having a rate of 200 dols. Many Cornell students have gone through on £100 per annum. On £150 or £200 a year a young man can get along comfortably, but I do not think one American student in fifty spends £200 a year. All of the universities give scholarships and prizes, and there are many ways in which an ambitious student can cut down his expenses. The university registers all give detailed information on these points.

ACTIVE WORK AND PROSPECTS.

The four years' course completed, the engineering student plunges at once into active work, accepting any salary, however small, which will give him a foothold with an important company. A few years ago the professionally-trained young engineer had difficulty in finding employment, but now that university training has been made so intensely practical, the demand for university graduates actually exceeds the supply. Positions for suitable men are available in steel mills, electric works, locomotive shops, shipyards, power stations, etc., many producing salaries of from £250 to £500 a year, with opportunities for rapid advancement.

AN ALTERNATIVE PLAN.

Graduates of English universities or technical schools, who do not choose to take an American engineering university course, can enter the "student department" of one of the great engineering works. If, for example, the young Englishman intends to follow electrical engineering, one of the places to go to is the General Electric Company at Schenectady, New York, where there are more than 400 graduates of the world's leading engineering schools. This is one of the principal homes of the electric industry, 10,000 men being employed making electrical machinery for all parts of the world. Every summer more than 150 young university graduates enter these shops, put on "overalls" and begin work in the testing department at 12½ cents. an hour. Under the leadership of experienced electrical engineers, the students receive instruction in the various departments of the vast works.

Directly a man shows evidence of worth, his wages are increased, and opportunity is afforded him of going ahead as fast as he will push himself. Bright men are picked out, and to them are offered positions of responsibility in the works, in other shops of the company, and on outside construction work. Many of the men strike out for themselves and obtain positions with other manufacturing companies, electric power and street railway companies. If they have ability they experience no trouble in finding renumerative employment. Many of the foreign students return to introduce American ideas at home. At the works this year there were fifty men from Cornell, forty from the Massachusetts Institute of Technology, and representatives of more than a hundred other institutions, including nearly every well-known engineering school of England, France and Germany.

RAILWAY ENGINEERING.

For the student who wishes to adopt a railway career, either as a railway mechanical engineer or an operating official, the Pennsylvania Railroad offers a course of instruction for students at its great shops at Altoona. When the writer was last in Altoona there were seventeen young men taking the special course, and it is interesting to catalogue them. They were : a Japanese prince, a graduate of the Imperial University of Tokio ; an English public school boy ; two Harvard University men, one a son of the late president of the Pennsylvania Railroad, the other the son of a millionaire dock owner ; two Princeton University men, one the son of a Pennsylvania official, the other the son of a United States Senator ; four Cornell graduates, one the son of a millionaire silk maker, another the son of a railway official, the third the son of Philadelphia's leading publisher, the fourth the son of a New York lawyer ; a student of Massachusetts Institute of Technology, whose father is a Judge ; two Yale University men, one from Purdue University, and another from the University of Pennsylvania.

The Altoona course, in its entirety, extends over four years, and includes work in the erecting shop (six months), the lathe shop (six months), the vise shop (three months), the air-brake shop (two months), the blacksmith's shop (two months), the iron foundry (two months), the boiler shop (two months), the freight car and passenger coach shops (six months) with "wrecking crew" practice, the round house (four months). After the student has "fired" an engine on the road, he spends two months in the shop clerks' office, two months in the motive power clerks' office, five months in the test room, and finally three months in the drawing room. This is perhaps the most rigorous course in America. In its thoroughness it is characteristic of the management of a railway which last year showed gross earnings of £40,000,000—a system which owns enough rolling stock to fill five tracks between London and Liverpool.

ENGINEER OFFICERS IN H.M. NAVY.

BY

D. B. MORISON.

A WELL-KNOWN steamship company recently advertised for a superintendent engineer; the advertisement appeared for one week, and there were four hundred and seventy-five applicants.

In contrast with this may be cited the fact that practically continuous advertisement by the Admiralty for engineer officers, accompanied by a lowering of the standard, has for a long time past yielded such inadequate and unsatisfactory results that, unless prompt measures be taken to deal with the vital question affecting the engineering personnel, the fighting efficiency of the Fleet will be very seriously impaired.

Engineer officers in H.M. Navy are at present recruited from the following sources:—

1. The Royal Naval Engineering College at Keyham, Devonport.
2. By examination for "Direct Entry."
3. By examination for "Temporary Service."

It was apparently the original intention of the Admiralty to produce the same homogeneity amongst engineer officers trained at Keyham as exists in the case of executive officers trained on the *Britannia*; but, as the real importance of the engineer personnel has never been appreciated by the executive officers at the Admiralty, Keyham College has been allowed to drift into such a very unsatisfactory condition that, whilst in 1898 there were six applicants for every vacancy, in 1901 there were only two. It is true that in the present year there has been a slight increase, but the value of the apparent improvement is indicated by the fact that four School Board boys entered at Portsmouth and passed the examination. One failed medically, and the remaining three refused to accept appointments; it subsequently transpiring that they had competed merely for educational practice, and with no intention whatever of entering the Navy. This year thirty-three candidates were accepted for Keyham, but no less than 73 per cent. were drawn from the agricultural counties of Devon, Hants, Kent, Surrey, Dorset, Lincoln, Herts, and Somerset. There was not one candidate from the great marine engineering centres on the Clyde or the North-East Coast, whence the best supply should naturally flow.

This anomaly is, no doubt, accounted for by the deterring influence of the more intimate knowledge pervading marine engineering circles regarding the disadvantageous conditions of service in the engineer branch of H.M. Navy.

In order to meet the great scarcity of candidates for Keyham College, the Admiralty, some time ago, issued a circular to the head masters of schools, urging them to send up boys for the engineering examination, but at the Conference of Head Masters held at the Guildhall, London, under the presidency of Dr. Jas. Gow, of Westminster School, the Head Masters' Association decided that they could not advise parents to embark their sons on so unsatisfactory a career as that offered by the engineer branch of the Navy, under existing conditions.

The supply from Keyham being inadequate, the Admiralty next introduced a system by which young engineers, who have received theoretical training in any of the technical colleges of this country, and practical training in any large engineering works, can compete by examination for "direct entry" into H.M. Navy as engineer officers. This system has also failed, as, at the examination held last month throughout the United Kingdom, only six candidates presented themselves, three of whom passed with a low percentage of marks, and it is a regrettable fact that not one application was received from the Durham College of Science at Newcastle, notwithstanding its chair of engineering, excellent engineering laboratory, and unsurpassed facilities for marine engineering education and training. The system of "direct entry" having thus hopelessly failed, the Admiralty decided to lower the standard of educational and practical requirements, and admit officers for so-called "temporary service." Although there was liberal advertisement, the result has been a complete fiasco, as no candidates presented themselves at the January examination, and only two in March, one of whom was accepted.

The Admiralty, however, are never at a loss for ineffectual and risky expedients when dealing with the engineer personnel, and the next step was to issue an order transferring engineering duties, in connection with hydraulic, pneumatic, and electric appliances on H.M. ships, from engineer officers to executive officers, and requesting the captains of the *Vernon* and *Excellent*, together with the chief inspector of machinery at Portsmouth Dockyard, to consider and report upon the methods best calculated to facilitate the adoption of the change, including the necessary courses of instruction. The captains drew up a scheme of technical and practical training, embracing, amongst others, the following items :—

Specifications for materials. Working drawings. Approximate estimate of the time and cost of each operation for the finished article. Different metals for different parts. File work. Filing round and square holes. Chisels. Using hammer and chisel. Tools. Tempers. Forging. Lathes. Cutting internal and external threads by hand and with machine. Drilling. Tapping. Soldering. Brazing. Burning pieces on a casting. Making rivets. Bushing holes. Putting on patches. Making steel and bronze nuts, electrical terminals and contact pieces. Following from start to finish every operation in connection with Whitehead torpedo. Testing fractures, patterns, material used, where procured, and price.

HOW TO BECOME AN ENGINEER IN 168 HOURS.

Any engineer knows that this course would, in accordance with the ordinary accepted methods, involve from five to six years of very hard work. Yet the captains of the *Vernon* and *Excellent* fixed the duration of the training at one month! Allowing twenty-eight working days at six hours a day, the total training would occupy but 168 hours. How to become an engineer in 168 hours? The proposition is so absolutely farcical, that one would dismiss it with a smile were it not for the knowledge that the gravest issues are involved in these nonsensical proposals, and that their translation into practice would sap the actual realisable fighting efficiency of every ship in the fleet.

The only value of the report apparently lies in the fact that it affords convincing evidence that the executive officers who submitted it cannot lay claim to the possession of even elementary engineering knowledge and experience, and it is this non-appreciation of engineering prevailing amongst executive officers of even the highest ranks which renders the question of there being no engineer officer on the Board of Admiralty one of national importance.

The chief inspector of machinery at Portsmouth Dockyard refused to endorse this scheme.

The present position is that, even on the attenuated and inadequate Admiralty basis, there is a shortage of fifty-one engineer officers, and this shortage will undoubtedly increase until the Admiralty decide to place engineer officers in H.M. Navy on the same basis as executive officers in respect of rank, pay, promotions, pensions, honours, etc.

THE PRESENT UNSATISFACTORY CONDITION.

It is obvious that engineers of education and experience will continue to refuse to enter the Navy as civilian officers with no military status. It should also be recognised by those who control the destinies of the Navy that engineering is a profession, and that, in view of the immense issues involved in the maintenance of the mechanical efficiency of our floating fighting machines, engineer officers in H.M. Navy should be gentlemen of the highest technical and practical attainments. Admirals of the old school, with no knowledge whatever of professional engineering, who in public venture to compare engineer officers to "Lascars with oil cans," refer to them in the press as "a scratch collection of the residuum of the engineering profession," and avail themselves of every other opportunity for depreciating and snubbing them, have contributed not a little to the present deplorable state of affairs, and it needs the strong hand of resolute statesmanship to overcome the intense traditional prejudice against engineer officers which is still promoted by many executive officers at every available opportunity.

There is no engineer officer on the Board of Admiralty; engineer officers cannot sit on Courts Martial; their signatures to their own reports are suppressed, and although there are officers from the executive, paymaster, and marine branches attached to the Naval Intelligence Department, there is no engineer officer. A well-known captain (R.N.), in writing to the press some time ago, exactly expressed the feeling entertained towards the engineer branch by executive officers, when he referred to it as the "alien profession" "*in* the service but not *of* it," and this studiously cultivated feeling of disdain is intensified by the action of the Admiralty in persistently lowering the standard in their anxiety to obtain engineer officers without increasing the attractions of the engineer branch.

LOWERING THE STANDARD OF ENTRY A DANGEROUS EXPEDIENT.

Unfortunately, the practice of lowering the standard of entry has already been so extensively adopted from time to time that its accumulative effect has at last appreciably diminished the homogeneity and average efficiency of the entire engineer personnel afloat.

Warships which were formerly in charge of officers of chief engineer rank are now in charge of junior officers, whose increased responsibilities are not compensated for by accelerated promotion, and many ships having engines up to 4,500 i.h.p., with Belleville and other water-tube boilers — which admittedly require highly skilled and experienced attention —carry no commissioned engineer officer, but are in charge of an artificer engineer.

The whole tendency of modern education is to raise standards in all professions, and with the immense and rapid developments in mechanical science as applied to naval warfare, the lowering of the standard of engineer officers is a highly dangerous expedient.

In view of the existing similarity between the earlier education and training of executive officers on the *Britannia* at Dartmouth, and engineer officers at Keyham College, Devonport, and the tendency towards a yet closer similarity created by the growing importance of scientific education for executive officers, a scheme for their common entry to the *Britannia* for joint early training in naval discipline, mathematics, chemistry, physics, etc., would commend itself as being likely to result in efficiency and popularity.

Those destined to become engineer officers would be subsequently transferred to Keyham for a thorough course of practical training in the dockyard, and a further training in applied science by lectures in the college.

Reforms, sufficiently radical and comprehensive to be successful, are to be looked for only in the direction of either the scheme proposed by the North-East Coast Institution of Engineers and Shipbuilders, or the new personnel system of amalgamation of the executive and engineer branches adopted in the United States Navy, *plus the compulsory performance by each officer, under definite regulations, of engine-room duties during an adequate proportion of his whole term of service.*

The pivot point, however, of this and kindred questions is human nature, and the partial failure of the new personnel system in the United States Navy is, in a great measure, attributable to the fact that officers have not been compelled by regulation to undertake a definite share of engine-room duties. The majority have, therefore, very naturally chosen to perform deck duties in preference to the relatively harder and less agreeable work in the engine-room, thus completely perverting the whole spirit and intention of Admiral Melville's scheme, which, had it either left less to the spirit and volition of officers, or been complied with by the latter in good faith, would, undoubtedly, have resulted in greater success.

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OUR MONTHLY RÉSUMÉ.

LONDON, 20th August, 1902.

The "Dead Season."

It is a curious fact that orders for ships are usually few and far between in the height of summer. Whatever be the reason, the period between May or June and August is what may be called the "dead season" in the shipbuilding world. But by about the middle of August if there is going to be any revival in demand it should be then apparent, for contracting is usually most active between August and November. The output also for July is generally a small one because of holidays. In Scotland, for instance, our largest shipbuilding centre, the Glasgow Fair holidays take a good half out of the working month, because even after the men resume they are "soft" and lazy for another week or so. There is, therefore, not much for us to record here of the month just left behind us as these lines go to press. There has also been a lull in the stream of sensational stories about possible or impossible Combines. The latest achievement seems to be that of Sir Christopher Furness, who, with Morganatic appetite, is credited with having absorbed the Gulf Line (of Greenock) with a capital of £250,000. With the very meagre details that are at present available it would be premature to speak too positively about the new Canadian subsidised line of steamers which is to run direct from Canada to South Africa. The statement at present made is that the Canadian Government has arranged to pay a subsidy of £30,000, and the British Government a subsidy of £15,000 a year, to a combination of the Allan, Wilson-Furness, and Elder-Dempster lines, which undertake to run a monthly service of freight and passenger boats between Canada and South Africa.

Quarterly Shipbuilding Return.

According to the quarterly statistics of Lloyd's Register it appears that, excluding warships, there were 406 vessels of 1,129,582 tons gross under construction in the

United Kingdom at the close of the quarter ended June 30th, 1902. The particulars are as follows, with figures for the corresponding period in 1901 :—

Description.	June 30th, 1902. No.	June 30th, 1902. Gross Tonnage.	June 30th 1901. No.	June 30th 1901. Gross Tonnage.
Steam.				
Steel	379	1,107,605	409	1,287,366
Iron	1	200	2	380
Wood and Composite	1	160	2	72
Total	381	1,107,965	413	1,287,818
Sail.				
Steel	12	20 428	15	10 948
Iron	—	—	—	—
Wood and Composite	13	1,189	13	1,413
Total	25	21,617	28	12,361
Total Steam and Sail	406	1,129,582	441	1,300,179

The present returns show a reduction in the tonnage under construction of about 111,000 tons as compared with the figures for the preceding quarter, and of about 284,000 tons as compared with the high total of September, 1901.

Lloyd's figures only include vessels over 100 tons each, and the following table gives the number and tonnage of merchant vessels (excluding warships) now under construction in some of the principal shipbuilding districts of the country as compared with those for the same period last year. Each district includes all places in the neighbourhood of the port after which it is named :—

District.		June 30th, 1902. No.	June 30th, 1902. Gross Tonnage.	June 30th, 1901. No.	June 30th, 1901. Gross Tonnage.
Belfast	Steam	21	185,752	21	190,071
	Sail	—	—	—	—
	Total	21	186,752	21	190 071
Barrow, Maryport and Workington	Steam	8	25,565	4	11,350
	Sail	1	150	3	450
	Total	9	25,715	7	11,800
*Glasgow	Steam	79	230,731	79	240,651
	Sail	8	13,603	6	4,014
	Total	87	244,334	85	244 665
*Greenock	Steam	42	139,080	52	156,610
	Sail	2	4,220	2	5,645
	Total	44	143,300	54	162,255
Hartlepool and Whitby	Steam	14	64,163	24	91,230
	Sail	—	—	—	—
	Total	14	64,163	24	91,230
Middlesborough and Stockton	Steam	24	69,353	30	112,275
	Sail	—	—	—	—
	Total	24	69,353	30	112,275
Newcastle	Steam	74	192,488	83	265,806
	Sail	—	—	—	—
	Total	74	192,488	83	265,806
Sunderland	Steam	42	155,058	50	178,549
	Sail	—	—	—	—
	Total	42	155,058	50	173,549

New Warships.

The following is a statement of the war vessels which are at present under construction. It has been assumed that a vessel may be regarded as "under construction" from the commencement of the laying of her keel to the time when she is ready for her steam trials. Of course, when this latter stage is reached, the guns have usually still to be placed on board, and the vessel to be fitted out before she is ready to be commissioned, but she is, nevertheless, structurally complete :—

Nationality.	Description.	Number.	Displacement. Tons.
British	1st class battleships	8	121,050
	1st class armoured cruisers	15	153,200
	2nd class protected cruisers	2	11,760
	3rd class protected cruisers	1	3,000
	Sloops	4	4,280
	Torpedo-boat destroyers	12	4,550
	Torpedo-boats	5	950
	Submarine boats	5	not stated.
	Total	52	298,790
Foreign or not stated	Armoured vessels	2	23,600
	Protected cruisers	1	4,000
	Torpedo boat destroyers	2	750
	Total	5	28,350
	British and Foreign total	57	327,140

Year's Shipbuilding in the United States.

During the fiscal year, which ended on June 30th, 1,657 vessels of 473,981 gross tons were built in the United States and officially numbered, compared with 1,709 vessels of 489,616 tons in the previous fiscal year. The decrease is in sailing vessels and canal boats, barges, etc. This year's new sail tonnage is 101,072 tons; last year's was 128,099 tons. This year's new canal boats, barges, etc., aggregate 57,502 tons; last year's reached 88,331 tons. New steel steamers aggregate 275,479 tons, compared with 235,265 tons last year. Included in the total new tonnage are 94 vessels each of over 1,000 tons, aggregating 315,062 tons, or two-thirds of the output. Of this construction 41 steel steamers of 158,631 tons were built on the Great Lakes. The Lakes have built for ocean trade two West India fruit steamers of 1,820 tons each, one cargo steamer of 2,182 tons, and two large cargo steamers of 5,270 tons each cut in two to pass the Canadian canals. The output of completed steel steamers on the seaboard has been much below the indications of last July. The launching of nearly every large steamer has been delayed from three to eight months, and some which by this time were to have been in operation are still on the ways. The delays have been partly due to the steel strike last summer, to the great demand for structural steel in all directions, to low ocean freights, and to the lack of new shipbuilding orders, which has left builders and owners without motive for haste. Last July 255,000 tons of ocean steel steamers were under construction or under contract, while at present only about 160,000 tons are under construction, and no new large seaboard contracts are reported.

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* Glasgow and Greenock figures include those for the Forth, Tay, and Dee.

The Boiler Question.

The Navy Boiler Committee which was appointed on September 6th, 1900, evidently consider that their work might very well be continued, as they seem unable to fix definitely upon a type of boiler which will serve all purposes, and yet be durable. There is, however, about their last report more of definiteness than characterised the preceding one. The advantages of water tube boilers for naval purposes are so great, chiefly from a military point of view, that providing a satisfactory type can be adopted, it would be more suitable for use in the Navy than the cylindrical type ; but the Committee are pronounced in their opinion that the Belleville boiler has no such advantage over other types as to lead them to recognise that as the best type to be adopted in the Navy.

The Belleville Boiler.

At the same time, they fully recognise that the Belleville boiler, when new and in sound condition, is a good steam generator, but its rapid loss of efficiency in ordinary work in commissioned ships, the serious character of the defects which have been developed in it, and the great care required in its manipulation render it, in the opinion of the Committee, undesirable to fit any more of this type in H.M. Navy. To obtain satisfactory results in working these boilers in the face of the disadvantages named, more than ordinary experience and skill are required on the part of the working staff. The Committee find that serious defects in the boiler casing have made their appearance in several instances, and have rendered the vessels in which they occurred unserviceable for long periods. Elaborate details of repairs indicate a very wide variation in the extent of defects, not only in the boilers but in the casings, and this notable feature has led to the conclusion that many of these defects are not inherent to the system but rather to the manufacture or to the supervision given on board.

Belleville Defects.

The Committee, in dwelling upon the defects, name several which are, however, inherent to the Belleville boiler system. These include the corrosive decay of the baffles in the steam collectors, and of generator and economiser tubes. This has now been greatly reduced by the use of lime and zinc, but great care has to be taken to prevent choking of the water gauge connections in consequence of the free use of the lime. The next is the rapid wear of the working parts of the automatic feed apparatus and the non-return valves in the down-take pipes. The third is the melting of fusible plugs owing to uncertain circulation ; the fourth, the deposit in the tubes about the water-line, but specially in the wing elements, due to impure feed-water and involving failure of the tube ; and the fifth, and last, is the excessive expenditure of coal and of fresh water for boiler-feed make-up, as compared with vessels fitted with cylindrical boilers.

Requirements.

The Committee point out that, as compared with the cylindrical boiler, satisfactory water-tube boilers should possess the following advantages : Less delay in steam raising ; less liability to damage if the boiler be struck by a projectile ; greater ease of repair and renewal of parts ; less weight for the power generated, considering the weight of the boiler installation only ; ability to carry a higher steam pressure ;

and larger fire-grate area for the same floor area, with consequent less forcing for full power. These advantages are possessed to a considerable extent by the Belleville boiler, and on the competitive trials of the *Hyacinth* and *Minerva*, the Belleville boilers proved more efficient as regards evaporation than the cylindrical boilers as originally fitted, but after the retarders were fitted in the latter the efficiencies were nearly equal. The long runs to Gibraltar and back also proved that in several respects, notably in the loss of feed water and in economy of coal consumption, as well as in immunity from accident during ordinary working, the cylindrical boilers were considerably superior to the Belleville.

Large Tube Boilers.

The Committee are still of the opinion that the Babcock and Wilcox, Niclausse, Dürr, and Yarrow large tube boiler, all of which are of the straight tube type, merit, as proposed in their first report, extensive trial in the Navy. These types have few of the disadvantages of the Belleville boiler with most of its advantages. They all have "drowned" tubes, and the water level, as shown by the gauges, is practically the level of the water in the boiler; they do not require a much higher pressure to be maintained in the feed pumps than in the boilers, nor in the boilers than at the engines; the use of automatic feed regulators of an extremely delicate type is not necessary; the circulation is fairly well defined, and is much freer than in the Belleville. From such experience and evidence as the Committee have had before them the loss of water will be much less than with the Belleville; and, finally, these boilers appear to be much more likely than the Belleville to be free from accident under ordinary conditions of service. The Babcock and Wilcox boilers in the Wilson Liner *Martello* made 91,000 miles running in fourteen months, with less than a week in port at the end of each Atlantic run, and the only repairs required had been those of the ordinary upkeep of any boiler, while only six tubes required renewal. Similarly satisfactory results are noted in connection with other merchant ships, and the same type of boilers in H.M.S. *Sheldrake* were found in good condition and had given little trouble. As regards the Niclausse boiler, the only expression of opinion is that those in H.M.S. *Seagull* are several years old, and have proved generally satisfactory. As to the Yarrow boiler, it is anticipated that the use of tubes of 1¾ in. in diameter will be more efficient and will give better results than the small tubes. Two methods of heating the air have been fitted in connection with Yarrow boilers in the Dutch and Austrian navies, one by means of tubes in the up-take, and the other by fitting an outer casing completely over the boiler and the up-take, and passing the air-supply through the space so formed.

Recommendations.

From the evidence it appears that no type of water-tube boiler at present in use is on general service so economical as the cylindrical boiler, and that a large percentage of the coal used is expended for auxiliary purposes in harbour. Until a thoroughly satisfactory type of water-tube boiler is obtained, the Committee recommend that in large cruisers and battleships cylindrical boilers of sufficient power to work the auxiliary machinery, and to drive the ship at her ordinary cruising speed, should be fitted, the steam pressure being the same for the water-tube and cylindrical boilers—210 lbs. per square inch—so as to give 200 lbs. at the engines. By this means considerable saving in coal will be effected. The water-tube boilers could, when not in use, be kept clean and perfectly efficient for driving the ship at high speeds when economy of coal relatively is not so important. The cylindrical boilers should be fitted with retarders in the tubes, and with special means for circulating the water while raising steam. The Committee recommend that retarders should be fitted in the tubes of all cylindrical boilers, believing that they will render existing boilers more efficient and more economical than at present. The former recommendation of the Committee to fit a combination of cylindrical and water-tube boilers has been carried out in the case not only of one of the battleships of the *King Edward* class, but also in the cruisers of the *Devonshire* class, the four types of water-tube boilers recommended—Babcock and

Wilcox, Niclausse, Dürr, and Yarrow—being utilised.

Small Tube Boilers.

Altogether, the Committee considered thirty-six boilers, out of which they made their selection of four, leaving the others for future consideration. As to the small tube boilers, they pronounced the opinion that they are unsuitable for vessels above the size of third-class cruisers; but Mr. List, one of the members of the Committee, thinks the Thorneycroft-Shultz is adapted for use in combination with cylindrical boilers, provided the tubes are not less than 1¾ in. external diameter, and of a given thickness; that the curvature of the tubes is such that a flexible cutter can be passed through them for the removal of scale; that the arrangement of the tubes is such that there will only be a small percentage of discharge from the tubes above the water line; and that there are no air locks in them when the boiler is filled right up.

The Awakening of the Railways.

One of the most important railway announcements of the month was that made by the Chairman of the North-Eastern Railway at their recent half-yearly meeting. In consequence of the increasing competition of electric tramways the Board has decided as an experiment to equip 37 miles of standard gauge line with electric traction. The section between Newcastle, Tynemouth, and Whitley Bay will probably be the first to receive attention. There are rumours that several of the other leading railways are contemplating similar decisions, and it seems probable that electric traction will soon be in vogue on some of the suburban lines of the London and South-Western Railway. Another gratifying sign is that greater attention is now being paid to automatic signalling devices. The South-Western Company has quite recently installed on its main line between Andover and Grateley a series of automatic signals, controlling five consecutive block sections, and in addition to this enterprise we learn that the North-Eastern Company are contemplating installing on their main line near York the "Hall" electro-automatic track signals which are in extensive operation in the United States.

The Coming Americanisation of the Goods and Mineral Departments.

The Americanisation of the passenger department, which is now in evidence on most of the British lines, will, in all probability, be followed by a similar development in the mineral and goods departments. Several of the companies are adopting—if somewhat cautiously—the large steel waggons of from 30 to 50 tons capacity, which have been the subject of experiment for some time, and they at last appear to have realised the importance of reducing the dead load proportion of their present rolling stock. As an illustration of the considerable numbers of these cars employed by our competitors, it is instructive to note that whereas there are not probable more than 80 to 100 in the whole of Great Britain, the Pennsylvania Railroad a week or two ago placed an order with a single firm in Pittsburg for 12,000 pressed steel cars of various types, *each of 50 tons capacity.*

Locomotive Piston Valves.

In the interesting paper read on July 30th before the Institute of Mechanical Engineers by Mr. Walter M. Smith, M.Inst.C.E., of the North-Eastern Locomotive Department, the author describes the form of piston valve which he invented and introduced in 1887, prior to which period piston valves had been experimentally tried, only to be discarded. It may be gathered from his paper that he kept mainly in view the following objects: (1) More efficient distribution of steam; (2) reduction in coal consumption; (3) diminution in the amount of power absorbed by friction in the valves and valve motion; (4) utilisation in actual efficient work of the power thus saved; (5) reduction in cost of repairs and in time occupied in repairs, owing to the simplicity of the general arrangement of cylinders and valve motion; (6) lessened cost of construction; (7) free release of water trapped in cylinders and consequent diminution of priming. These are, of course, points of much importance. It is most desirable to reduce coal consumption and repairs-cost where possible, but not at the cost of diminished efficiency. Mr. Smith claims that his valves, while saving expense in coal and repairs, are not subject to this drawback. With regard to lowered coal consumption, his figures certainly show valuable results, a saving of 9·1 per cent. and 13·3 per cent. respectively being recorded as shown by the first goods engine and express engine fitted with his valves. Moreover, Mr. Smith states that the wear is so very small as to be almost inappreciable; thus his valves lessen the cost of upkeep by rendering less frequent the need of renewal. It is mentioned that North-Eastern engine No. 2,011, the first of a new four-coupled type which came out in 1899 and was fitted with these valves, had run 139,543 miles up to the end of the year 1901, without any appreciable wear in the valves or valve-gear being discernible. Theoretically, without doubt, the advantages of piston-valves are great, and in the instances cited by Mr. Smith they appear to have been realised in actual practice. But a further and more extended use of the method would seem to be desirable before any definitive opinion can be expressed as to the superiority over other valve systems which is claimed for them. It may be admitted, however, that hitherto the weight of evidence based upon experience—so far as precise results have been formulated—apparently goes in their favour.

The Labour Difficulty in South Africa.

There are abundant anticipations of a "boom" on the Rand, but no trustworthy signs of it. On the contrary, the lack of one of the essential elements presents an almost unsolvable problem. In June, 1899, the mines of the Witwatersrand were employing 97,800 natives, and it was estimated that another 15,000 were required to bring the force to its full complement. In addition to those natives actually employed at the mines, there are great numbers employed at Johannesburg and on the Rand as house-boys, drivers, cooks, and in other domestic work. The number of these may be estimated at about 30,000, and there will be quite another 30,000 employed on mines in mining towns outside of the Rand; so that the mining industry of the Transvaal may be calculated to give employment to a grand total of over 150,000 natives. The demand is now estimated at upwards of 200,000.

The Number of Natives at present Available.

What is the situation to-day? The returns of the Native Labour Supply Association show that up to June 30th 42,800 natives had been recruited by it, and 42,060 distributed to the mines. This is so much below the actual requirements that a great many gloomy predictions are being made, and the impatience of the mining public is undoubtedly increasing. The staff of the Association are, however, not discouraged, but are sanguine that from the present month the supply should commence to reach a monthly total of 7,000, enlarging gradually to 10,000 by December next. Accepting even these figures, it is apparent that some considerable time must elapse before the quantity of men available reaches the 200,000 the mine owners think they will require. The white skilled miners are also regarding with great suspicion the offer of some of the mining companies, to unemployed whites, of five shillings a day, with shelter and rations, for a ten hours day—six on Saturdays. This they think is the thin end of the wedge for a reduction of miners' wages all round.

Sinking Pumps.

A point much neglected, but of considerable importance in mining operations, has been recently considered at a meeting of engineers at Leicester; that is, the employment of a proper pump in sinking operations. At this meeting well-sinking was under consideration, but the question becomes far more urgent when the more serious operation of shaft-sinking is in contemplation. The usual plan is to buy the cheapest pump, whether it be suitable or not, and as a rule the result is deplorable owing to the various parts of the apparatus giving way in course of work. But it was shown that, provided due care is observed, pumping operations can be carried on with ease and expedition without any of the troubles incident to the practice just mentioned. The most suitable pumps should be employed, and with them what is equally important, suitable tackle and winches. This point has been very much neglected in the past, because the tackle and winches cost roughly double as much as the pump. But, properly provided with these appliances, it is certain that progress will be twice as great as by the old-fashioned system. Some of the better makes of suspended steam pumps are regarded as the most suitable, hung by long link chains, so that a shackle can be put on the chain at any link, and lifting appliances tackled on at any point in a few moments. The lifting tackle should consist of steel wire ropes and blocks with a winch, single or double-barrelled as circumstances may dictate.

Shaft Sinking by Percussive Boring.

Some excellent sinking has recently been achieved by means of Herr Pattberg's sinking appliances. These consist of a cutting-head mounted on a strong wooden or wrought iron frame-work, supported by a tubular boring rod, two mammoth pumps, the whole slung from a scaffolding over the shaft, and an oscillating drum and engine for giving the reciprocating motion to the cutter system. The accessories are water pumps and air compressors.

The work that has recently been done consists of three sinkings in two shafts 21 ft. in diameter through loose ground consisting of sandy clay, clay, quicksand, sandy marl, and accreted marl. The first sinking was 145 ft. in forty-four days, the second a little over 95 ft. in eleven days, and the third 188 ft. in fifty-nine days. The greatest speed obtained was 16½ ft. each in two successive days. The whole piece of work compares remarkably well with any other method of sinking.

The operation consists of lifting the cutting head and letting it drop 7 or 8 inches, fifty or sixty times a minute, giving a turn each time. The borer consists of a series of cutting edges or chisels, or of a continuous cutting edge, set obliquely in the frame so as to cut a surface inclining towards the centre; the operation takes place with water in the shaft, and, moreover, water under pressure is forced down the hollow boring rod and escapes by special channels at each chisel. The detritus and muddy water run to the centre and thence are lifted to the surface by the mammoth pumps, which comprise an inner and an outer pipe, and down the annular space between the two compressed air is forced, and at the lower end escapes into the inner tube and carries with it the detrital sludge.

Sinking drums are employed at the start, and continuous tubbing is made to follow the progress of the cutting head by means of hydraulic presses. Germany was the scene of this successful piece of work, and at the pit "Rheinpreussen IV." the total cost of a completely new installation and plant was £10,165, including everything, from pit frame and foundations to the air compressors, hydraulic presses, pump, and engines. The cutting-tool, mounted in a wooden frame and with a cutting edge of 21 ft., is 27 ft. high at the centre, and weighs 19,900 lbs.

A Recent Winding Engine.

"Made in Germany" applies to the most recent addition to France's winding engines for use in one of her coal mining enterprises. A German-made winding engine, constructed for the Société des Houillères de Ronchamp at Ronchamp, in the department of Haute Saone, has many special features. Spiral drums as well as taper ropes are used, and the engine is a twin-tandem compound engine, with separate condenser. The drums are installed at right angles to the long axes of the cages, and they are placed on parallel axes one in front of the other, the one nearest the pit head winding on the nearest cage, the other winding the farther cage. The pulleys are set in the frame one above the other. The large diameters of the drums are set both on the same side.

All points of compensation and safety have been particularly considered, special attention having been given to the positions of the drums and engines, the depths of the grooves in the spirals, the general construction and slope of the conical part of the drum, the prevention of overwinding, the ready manipulation of the engines, and steam economy.

The chief dimensions are: diameter of high-pressure cylinders, 27·56 in., of low-pressure, 39·40 in., stroke, 70·8 in., width of drum, 12 ft. 6 in., diameters of drum—largest, 35 ft. 5 in., smallest, 13 ft. 7 in. The wire ropes have a total length of 3,890 ft., include five different diameters, ranging from 1·77 in. to 2·28 in. and each rope weighs 14,404 lbs., of which 3,394 ft., weighing 12,257 lbs., will be generally in use; the rest is made up of some spare laps on the drum, and a length available when required in the sump. The work to be done under ordinary conditions is to lift 5,026 lbs. of coal 3,280 ft., the total load with cage, rope, and waggons being 27,292 lbs.

The frame of the drum is of wrought iron, and it is covered with plates to which the rolled sections of the spiral are rivetted.

Ore Concentration by Oil.

A process attracting some attention in mining and metallurgical circles is that in which oil is being employed to separate certain metal-bearing minerals from the valueless rock with which they are found associated when brought out from a mine. It is well known that from time immemorial advantage has been taken of the difference in specific gravity to separate the small quantity of valuable and heavy mineral from the vastly preponderating mass of rocky and lighter mineral matter, and multitudinous have been the appliances and practices devised to utilise to the best advantage the superior massiveness of the valuable mineral. In a gold mill anything in the way of greasiness was regarded with particular horror, but by the efforts of the originators of the new process all this is changed. Greasiness, represented by oil, is welcomed in abundance, and the chief object in the operation is to reduce the superior heaviness of the valuable material to such a degree as to make it float on water, whilst the valueless rock is allowed to sink.

This is achieved by mixing the pulverised ore and water with heavy petroleum oil. For some unexplained reason this entraps the valuable mineral and bears it up to the surface of the water, whilst the useless rock is discarded and remains beneath the water.

The appliances for carrying out the operation are very simple. The mixing and principal separation are done in long horizontal cylinders provided with a conveyor worm and baffles. The ore-bearing mixture is admitted at one end of the cylinder and the oil is allowed to drop in. The cylinder is caused to revolve, and so, accompanied by much mixing up, the oil, water, and ore travel automatically along the cylinder, and at the end of the journey they pass into a separating chamber. The ore with its valuable burden is run off, whilst the water with its rock is disposed of in any convenient way. The oil and concentrates are treated in centrifugal machines, by which the liquid matter is separated from the solid, and the latter (the concentrates) are ready for any further treatment that may be desired.

Gravity Work.

It is remarkable, however, what can be done by making use of the difference in specific gravity. Of this there are indeed innumerable examples dating back to times when records were first made, but there are few more striking than a recent experience in California. Two years ago, during nine months' work, 655,657 miners' inches of water removed 1,251,399 cubic yards of material, consisting of pay-gravel, varying from a few inches to 8 ft., with a barren overburden of the usual miscellaneous character, and varying in thickness from 50 to 130 ft. There was only a little over five farthings' worth of valuable material per cubic yard of material washed; nevertheless, by the ordinary means of washing away the lighter stuff and leaving the heavier to accumulate automatically, the operation was conducted at a profit.

Improvements in Galician Ozokerite Mines.

It is noteworthy that, after years of desultory working, the Galician ozokerite deposits, some attempt at systematic working is now being adopted; and a very complete installation is being introduced by the Galician Credit Bank on the Boryslaw field. The shafts are being properly protected, surface water tubbed back, pumps introduced to deal with the water in the deposits, ventilating appliances and electric light introduced, and, where necessary, the shafts are being deepened and well-protected loading stations provided. The main result will be that much poor stuff that has hitherto been wasted will now be brought to surface, and it is supposed will more than repay the cost of the improvements, without considering other advantages that must accrue.

Coking Indifferent Coal.

It is the custom nowadays to bewail the exhaustion of our coal supplies, therefore any suggestion relating to the better utilisation of coal should be duly welcomed. In England we have long adhered to the old and wasteful beehive method of making coke. After some half a century of persuasion, however, a few manufacturers have been prevailed upon to introduce the chambered oven system, and this method is now distinctly gaining ground. It is interesting to note that coals which cannot be regarded as coking coals, and which under the old condition of things could never have been used for coke, are now being converted into serviceable coke in chambered ovens. This is effected by compressing the finely divided coal employed before charging into the oven. The apparatus used consists of a deep rectangular trough about the size of the oven chamber, which is made adjustable to suit the size of any chamber; in fact, the bottom is movable and can be slid along, whilst both the ends and sides can be released when required. This trough, with accessory paraphernalia and the charging ram, is brought in front of the chamber to be charged. The coal is fed into the trough, and by means of a travelling mechanical stamper is compressed all along to the desired condition. The ends are then removed, the sides released a little, the oven door opened, and the block of compressed coal, along with the movable bottom of the trough, is pushed by the ram into the chamber. The door of the chamber is then partially closed, the bottom of the trough withdrawn, the door of the oven completely closed and luted, and a larger and better yield of coke is the result.

LOCOMOTIVE ENGINEERING NOTES.

Large and Small Railways

A CORRESPONDENT expresses the hope that the larger railways will not receive sole attention in these notes, but that some of the smaller lines will have a "look in" now and then. Most undoubtedly they will, relatively to the importance or interest of the work done, alike in the design and construction of new engine types, the improvement of old forms, and the results in respect of actual performances. It must be borne in mind, however, that the larger railways, as a rule, provide not only a greater volume of material for comment, but also often topics of superior interest, *per se*.

Eight-coupled Goods Engines.

Reference was made in the July notes of this series to the increasing use of the eight-coupled locomotive types for goods and mineral traffic in Britain. It has been pointed out that eight-coupled engines were used in Britain even before Mr. Webb introduced the type on the London and North-Western Railway, and therefore long before the Great Northern, Lancashire and Yorkshire, North-Eastern, Caledonian, and Great Central followed suit! Certainly, that is so. But the point intended to be emphasised was not the novelty of eight-coupled locomotives, but the extension of their use in Britain. Even in the United Kingdom they are no novelty, while, of course, the type is as "old as the hills" on the European and American Continents and in the British Colonies. Many years ago—in Mr. Archibald Sturrock's time—two eight-coupled tank engines were in use on the Great Northern, Nos. 474 and 475. But there was a prejudice against coupling so many as eight wheels, just as there was against using four-coupled engines on express trains, and as there has been in Britain, until lately, against using six-coupled locomotives on express work. But elsewhere the great advantage of having eight points of rail-contact in slippery weather has long been recognised, and now that this has at last obtained appreciation also in Britain, it is safe to predict that the type will never disappear while steam locomotion remains the standard mode of carriage. And electric traction has still much to learn before it can supersede steam on long-service.

A Condemned Electric Locomotive.

Many readers will remember the introduction, with many a flourish of trumpets, on the Western Railway of France, of a new electric locomotive that was to "whip creation." It was known as the Heillmann Locomotive, and was a sort of hybrid, being a steam engine and an electric-motor combined. The steam engine did not propel the locomotive, but simply actuated a machine by which the steam power was converted into electric force which propelled the engine. It was a vast and most ponderous machine, weighing well over 100 tons, and it was reputed to be capable of speeds quite American in their marvellousness. Of their actual attainment, save on paper, no authentic records exist. It is to be feared now that none ever will exist, for this marvellous engine was condemned to be dismembered, and its steam and electric-motors, all separated from one another, are said to be doing useful service in various *stationary* capacities. But as a locomotive the Heillmann no longer has any individual or collective existence. It may therefore be safely inferred that it was not a success or the harbinger of a new epoch-making class.

Multiplication of the "Atlantic" type.

There is a distinct indication at present that the so-called "Atlantic" type of express passenger engine will share with the six-coupled bogie type the bulk of the express services of the future. The six-coupled "Atlantic" arrangement is undoubtedly an effective one. The four-coupled driving wheels are right under the middle of the engine-length ; the front end is carried on a four-wheeled bogie which "holds down" the road for the driving wheels, and there is a pair of trailing wheels under the foot-plate which averts any "tail-wagging," and permits the use of as large a fire-box as can be stoked by any human stoker of normal dimensions. Since the pioneer of that class, the well-known "No. 990" was put on the Great Northern by Mr. Ivatt, ten more have been added with very satisfactory results. But so far the total number of the class remains at eleven on the Great Northern, whereas some fifty of the eight-wheeled "1321" class, which came out almost simultaneously, have been built at Doncaster. These latter are, doubtless, much cheaper to construct, and do excellent work, but one would imagine that the advantages possessed by the "Atlantics" would in the long run outweigh their extra cost. That, however, is a pure matter of experiment and experience which no amount of theorising can possibly determine.

Lancashire and Yorkshire "Atlantics."

But although the "Atlantics" have not been multiplied on the Great Northern, their numbers are steadily increasing on the second, and indeed only other, British railway that has tried them, viz., the Lancashire and Yorkshire. Up to the beginning of the current year forty of the "1400" class originally designed by Mr. Aspinall had been brought into service on the Lancashire and Yorkshire, and during the current year a fresh batch has been turned out by his successor at Horwich, Mr. Hoy. They appear to have proved highly successful in all respects, and certainly have done by far the best work ever seen on the Lancashire and Yorkshire. It is noticeable, moreover, that the duty demanded of them is of a class very different from that which had to be tackled by the earlier locomotives of Mr. Aspinall's-build, and those of his predecessor, Mr. Barton-Wright. The Lancashire and Yorkshire, formerly one of the slowest of British railways, is now among the fastest. The mere fact that it runs no fewer than twenty-nine daily expresses between Manchester and Liverpool, each booked at an average start-to-stop speed of virtually 55 miles an hour, is sufficient to place it in the first British speed rank, the latest North-Eastern and London and North-Western developments notwithstanding. It is curious that this very useful, although perhaps expensive, type of locomotive should, like the four-cylinder compound, find such limited acceptance in Britain, although so largely in use and useful in most other countries.

American "Atlantics."

In the United States of America, and also in Canada, the possibilities and advantages of the "Atlantic" type have long been fully grasped and utilised. Most of the famous trains on the American Continent are worked by locomotives of this class. Could it claim no other merit than its ready and convenient admission of a vast boiler and firebox, this alone would constitute an enormous recommendation in these days, when the combination of great power with large speed-capacity is an absolute essential in the modern express locomotive. But its other advantages of arrangement are so obvious as to need no elaborate demonstration.

French "Atlantics."

On the Northern Railway of France the success of the "Atlantic" or "Exposition" type, specially designed by Monsieur du Bousquet to meet the rapidly-increasing speed and weight of the fine express trains run by that company, has been so marked and so remarkable as to consitute an epoch in French—and, indeed, in European—locomotive practice. It will be remembered that two pioneer engines of this order, Nos. 2.641 and 2.642, were originally delivered simultaneously in the "Exhibition Year" 1900, the one to be shown at Vincennes, the other to run "parade" trains outside on its regular metals. In these engines, although certain standard details, such as the de Glehn system of four-cylinder compounding, the Walschaert valve-gear, etc., are adhered to, the locomotive itself is of absolutely new design, and the result has proved that Monsieur du Bousquet has produced an engine which assuredly has no superior in the world for express duty, if, indeed, it has any rival on all points, which is at least doubtful. Certainly no European locomotive holds such records for associated speed and weight-pulling. Eighteen more have been added to the original two, making twenty in all, and the last of the batch, No. 2,660, was only delivered at the end of July in this year. These eighteen are virtually identical with the first two, save in having six-wheeled instead of eight-wheeled tenders, the first and second pair of wheels being widely separated in order to leave space for the water-pick-up scoop with which these newest locomotives are also fitted, it being intended to lay down water-troughs at no fewer than five different points by no distant date. Other French lines are using engines of the "Atlantic" type, the Chemin de Fer de l'Etat, or State Railway, for instance, which imported several of these from the Baldwin Works in Philadelphia, U.S.A. Some of a similar type, also American in build, are likewise in use on the P.L.M. line, and it is understood that some on the de Glehn compound principle have been ordered by the Paris-Orleans Railway. But now the Chemin de Fer du Midi, or Southern Railway of France, has followed suit, and has ordered for its Bordeaux-Cette service two "Atlantics," which are to be exact reproductions of Monsieur du Bousquet's Nord "Atlantics," and which, like them, are to be built at Belfort by the Société Alsacienne de Constructions Mécaniques.

Dutch "Atlantics."

The "Atlantic" type has also been adopted in Holland as the new standard express type of the State railways. The Dutch "Atlantics" are in a large measure mere amplifications of the eight-wheeled four-coupled locomotive, which was previously the standard, and one of which, built by Messrs. Neilson, Reid and Co., was shown at the Paris Exhibition of 1900. Practically, that design of engine has been taken and lengthened as to its boiler and firebox, and a pair of trailing carrying wheels added under the footplate. In this way a very fine and useful locomotive has been evolved, and there is little likelihood of any reversion to earlier types now that the newer design has been afforded an opportunity of proving its value.

Belgian and Scottish Engines.

When the Chemin de Fer de l'Etat Belge, or State Railway of Belgium, deliberately adopted the "Breadalbane" or improved "Dunalastair" locomotive type, designed by Mr. J. F. M'Intosh for the Caledonian Railway, as the standard passenger class for that system, it was originally understood that these engines were specially intended for use on the heavier grades which are found on the Etat Belge system as it approaches the German frontier at Herbesthal. Five were built by Messrs. Neilson, Reid and Co., of Glasgow, to Mr. M'Intosh's designs, and were duly sent to Belgium. They gave such satisfaction that they have since been largely multiplied in their adopted country, many being constructed by Belgian firms, and these now are employed on the International express between Brussels and the French frontier, as well as in the German direction, replacing the older type with Belpaire fire-boxes, two middle pairs of wheels coupled, and rectangular funnels. Engines of the "Caledonian" type now come right into France, as far as Aulnoye, 134½ miles from Paris. It is noteworthy that Mr. M'Intosh's "Caledonian" design of goods engines was also adopted by the Belgian State line, and the two shown at the Paris Exhibition were of this pattern—high compliment to their designer and to his country!

NOTABLE BRITISH PAPERS OF THE MONTH.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of Great Britain.

MECHANICAL APPLIANCES IN MINES.

At the Newcastle meeting of the Institution of Mechanical Engineers, Mr. R. H. Wainford, M.Inst.Mech.E., contributed an important paper on the subject of Coal Cutting and Drilling by Machinery. The advantages of this method over hand-labour are clearly demonstrated.

ADVANTAGES OF CURVING OR HOLING BY MECHANICAL METHODS OVER HAND-LABOUR.

Generally the machines do this work under the coal, whereas the miner holes in the coal, and from a commercial point of view a distinct gain in favour of machine practice is established, there being a reduction in the amount of slack made. Something like 90 per cent. of the coal got by machines will pass over a ⅞ screen mesh, as against 60 per cent. by the hand method. For the purpose of ascertaining the difference in selling values an exhaustive trial was made at a Lancashire colliery with these results :—

		£	s.	d.
* Hand-labour :	3 tons coal at 11s. per ton ...	1	13	0
	1 ton slack at 7s. 3d. per ton...	0	7	3
	Value per ton, average, 10s. 0¾d.			
By machine :	8 tons coal at 11s. per ton ...	4	8	0
	1 ton slack at 7s. 3d.per ton ...	0	7	3
	Value per ton, average, 10s. 7d.			
	An increase of 6¼d. per ton in value.			

The foregoing figures are the result of work performed some time ago by a Winstanley disc coal-cutter, similar results are maintained at the present time, and whereas a miner produces 3 tons of coal to one of slack, a machine will get 8 tons of coal to one of slack. This advantage is somewhat discounted by the fact of slack being nearly as valuable as coal for coking purposes ; a better quality of coke is, however, made from disintegrated coal than from slack, as it is free from dirt—an element not entirely overcome by washing. If the coal is house or steam coal, then the advantage is fully maintained.

Therefore if 6¼d. can be realised in this manner, the amount may reasonably be placed to the credit of mechanical appliances, and then more than half of the shilling suggested as the possible saving is established.

A DIRECT COMPARISON.

For the purpose of making direct comparison as to the work of machines *v.* hand-labour, it is advisable to fix upon normal conditions, and to do this a three-foot seam may be reasonably and fairly regarded as the average. Coal can be holed by machines in this thickness to advantage; as they get thicker the saving is decreased, and as they become thinner they increase ; the machine may cease to show a gain when the thickness exceeds 5 ft., on the other hand the best results have been attained in seams under 2 ft. thick. A good miner will hole, curve, get, and fill three tons a day of eight hours in a three-foot seam under normal conditions, and in so doing will have earned, say, 7s. 6d. ; the cost for " holing or curving," getting and filling is therefore 2s. 6d. per ton. There is little doubt as to this figure, viz., 2s. 6d. per ton, being below the average on the total output of Great Britain, so the rate may be accepted.

CAPITAL OUTLAY.

The capital outlay for a complete coal-cutting plant is here considered, with allowances made for interest on capital, depreciation, repairs, cost of running, stores, etc., and a figure arrived at to stand against the machine.

The estimated cost of a single coal-cutting machine plant :—For one machine complete with all fixings and power plant, exclusive of boiler, engine house and foundations, £1,000 ; the standing charges are as follows :—

	£	s.	d.
For interest and depreciation at 15 per cent. per annum of 300 working shifts	150	0	0
For repairs and stores	75	0	0
For power (fuel)	60	0	0
	£285	0	0

£285 ÷ 300 = 19s. per shift.

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* These figures are taken from the recently published book by Sydney F. Walker, page 48, "Coal Cutting by Machinery in the United Kingdom."

The specification of a single machine installation complete, as estimated above, includes engine and dynamo, electric standard type coal-cutter and all accessories and connections from the generator to the machine at a face half a mile from the shaft, erecting the plant and running it for ten days. No account is taken for attendance at the generating station. It may be here suggested that when the cutters are worked on the night turn, which is usual, the fuel account would hardly be appreciable, as the steam in this case will be drawn from boilers that are not in use although in steam.

This is for an electric installation; the compressed air plant may be taken over all to be about equal in cost. Some slight differences occur in the prices for the Hurd, Clarke-Stephenson, and Diamond; the sum £1,000 is not exceeded, however, in any case.

The coal-cutter will hole or curve to a depth varying from 3½ ft. to 6 ft.; the average working depth is 4½ ft., and in eight hours will travel across a face seventy yards under normal conditions, holing or curving through a distance on the face, which when got and filled equals 100 tons; the same falling-off and increase in the make applies here, so the average may be taken as stated. Sometimes two men only are required to look after the machine, and never more than three; if these men are paid at the same rate as the miner, the holing through seventy yards will then cost 7s. 6d. × 3 = 22s. 6d., less if anything, because two men may be enough to do the work.

For getting down and filling (11d. per ton standard + 57½ per cent.), cost per ton = 1s. 6·46d., and the total for holing or curving, getting and filling 100 tons is :—

	£ s. d. per ton.		s. d. per ton.
For special machine men (holing)	1 2 6	or	0 2·7
.. getting and filling	7 13 10	„	1 6·46
.. holing, getting, and filling	8 16 4	„	1 9·16

Bringing forward the amount estimated as the standing charge per shift against a single machine plant, we have the following results :—

	£ s. d. per ton.		s. d. per ton.
For holing, getting, and filling 100 tons	8 16 4	or	1 9·16
„ standing charges, interest, etc., 100 tons ..	0 19 0	„	0 2·28
•	9 15 4	„	1 11·44

The reduction, therefore, is 6·56 pence on the 2s. 6d. rate in favour of the machine, and, together with the amount previously estimated as savings due to increased selling value, etc., of 7·25 pence = 13·81 pence. The unfavourable points in the foregoing estimates are found in the fact that, whereas a single-machine plant is put down at £1,000, a two-machine plant costs £1,575, a three-machine plant £2,125, and a four-machine plant £2,950 approximately.

ADVANTAGES OF COAL-CUTTING MACHINERY.

When coal-cutting by machinery is efficiently carried out, the working face is kept straight and clean. Undercutting to greater depths than possible by hand renders timbering required less frequent and therefore less costly, and also a reduction in the number of shots to be fired is found from experience to be considerable. By keeping a straight, line the coal breaks away more easily, especially when aided by increased depth of hole. At a mine in Yorkshire forty shots were fired per day when the holing was made by hand; the machine method reduced the number of shots necessary to seven. Another good feature in the new method to be noted is that work can be carried on regularly; to keep a face moving forward at a set speed, varying conditions are minimised, and so the work becomes easier to cope with and less hazardous.

POSSIBLE PRACTICAL OBJECTIONS TO MACHINE PRACTICE.

From the practical point of view some objections to machine practice occur; they present themselves differently in each mining district; discussion may indicate them variously. One of the chief objections to the system is the difficulty in finding men to attend the machines, possessing sufficient mechanical skill and pit experience to enable them to cope with contingencies at the face as they are met; but this hardly reflects discredit upon the mechanical methods directly. Miners can readily apply themselves if dealt with with tact and encouraged in the work. At some places machine methods have recorded a failure, traceable very often to the plant being either badly designed or lacking the necessary power, but most often to the system being taken up in a desultory manner, for it seldom happens that a new idea does not meet serious difficulties, due to prejudice, either on the part of the management or the men, or both.

COST IN YORKSHIRE.

The author concludes with some very interesting figures, which we give below :—

Total underground cost of working a seam 3 ft. 3 in. at a depth of over 500 yards in a Yorkshire Colliery by means of the "Diamond" deep undercutting machine, holing to a depth of 5½ ft. in stiff fireclay.

	Cost per ton. s. d.
Coal getting (11d. per ton standard price, including 57½ district percentage) ..	1 6·46
Coal-cutter men, paid by day	4·82
Cleaning up, ripping (9 ft. roads), horse-keepers, hurrying and hanging on, main roads, bye work, and superintending, including deputies, shot-firers, etc. ...	1 1·91
	3 1·19

Approximate output from seam, 4,500 tons per week.
Average tonnage for fillers, 6½ tons per shift.

LIQUID FUEL FOR STEAMSHIPS.

MR. EDWIN L. ORDE, of Newcastle, in the course of a paper read at the recent meeting of the Institution of Mechanical Engineers, attributed the slow advance made in the use of liquid fuel for steamships to the fact that until comparatively lately it has not been obtainable in such quantities as are required to make it commercially useful.

For many years the Caspian Sea was the only place where liquid fuel was used in the furnaces of marine boilers, and as the quantity available was not sufficient to allow of its export, it could only obtain a very limited application. Of late years, however, the sources of supply have largely increased in number, and now that the large oil-fields of Borneo and Texas are in active operation, and commercial enterprise only needs the stimulus of demand to organise distributing stations, the question of the adoption of liquid fuel on a large scale appears to need for its solution only the close attention of engineers. The principal sources of supply are the fields of Borneo, Burmah, the Caucasus, Texas, and California ; but there appear to be indications that further supplies exist, and were the demand assured, would be explored and developed.

ITS COMBUSTION IN BOILER FURNACES.

The conditions that attend and the reactions that take place in burning liquid fuel in boiler furnaces present a problem which has apparently not received the attention which it deserves. Petroleum vapour depends entirely on temperature, and it is therefore almost impossible to collect samples when actually burning it in a furnace. It seems obvious that the first effect of the furnace heat on the petroleum spray is to liberate hydrocarbon vapours, and to ignite them on the outer surface of the jet. The ignition raises the temperature of the whole of the jet, and probably dissociates some at least of the hydrocarbon vapours into carbon monoxide and hydrogen. In what form the undissociated hydrocarbon vapours burn it is difficult to conjecture, but the appearance of the flames suggests that acetylene is present. This might conceivably arise from the reaction $CH_4 + CO = H_2O + C_2H_2$. As the temperature of the flame rises, the hydrocarbons are probably all dissociated, and burn as CO and H to CO_2 and H_2O without further change. When the conditions are satisfactory, the flames are opaque and dazzling white in colour for a distance of some 6 in. from the nozzle of the burner, become semi-transparent, and almost violet in colour at the middle of their length, and shade into red at the end. In burning oil which is mixed with water the combustion is incomplete, the violet colour never appears, and the end of the flame is dark red and fringed with smoke. In some cases, where water is present in comparatively small quantities, the end of the flame is white, and presents the appearance of acetylene, which may arise from want of sufficient heat in the flame to decompose the hydrocarbons. This has been observed when, although no smoke was formed and the air supply was not more than 20 per cent. above what is chemically necessary for the fuel, the evaporative performance of the boiler was poor, which confirms the existence of a low furnace temperature.

APPARATUS DESIGNED FOR UTILISING LIQUID FUEL.

The "burners" which have been designed for admitting liquid fuel into boiler furnaces, numerous as they are, may be broadly divided into three distinct types. These are :—

1st. Mechanical spray, in which the liquid fuel is forced under pressure through nozzles, made of such a form as to break it up into a fine spray and thus render it inflammable.

2nd. Spray burners, where the liquid fuel is held in suspension and driven into the furnace by means of a jet of steam and compressed air.

3rd. Vapour burners, in which the liquid fuel is volatilized and the vapour admitted to the furnace.

ARRANGEMENT FOR SEPARATING WATER.

In addition to the actual burning apparatus, no installation can be considered complete without (*a*) some form of filter to cleanse the fuel oil of impurities, and (*b*) some arrangement for separating water. This last is by no means so simple as it would at first sight appear. The specific gravity of most fuel oils is about 0·92 to 0·96, so that separation by the action of gravity alone is an exceedingly lengthy process and practically never complete ; but as the coefficient of expansion of fuel oil is considerably higher than that of water, the action may be greatly hastened by heating the contents of the tank ; the combination of oil and water, however, is curiously intimate, and a careful experiment showed that at a temperature of 140° F. seven days elapsed before the water was completely separated. A large expenditure of heat is required if the contents of the fuel tanks are to be maintained at such a temperature, and it is obvious that, unless the separating process is complete and the water is all drained out of the tank before any of the fuel is drawn off for use in the burners, the lower layers, which are the first to flow, are formed of a concentrated intermixture of oil and water. One way out of this difficulty consists of a swing pipe supported at one end by a floating vessel. The orifice of the pipe is arranged at a suitable distance below the surface of the liquid fuel, and a coil of steam pipe is fitted so as to raise the temperature of the oil immediately surrounding the opening into the pipe ; the fuel passes through the swing pipe on its way to the burners, and is to a great extent freed of water at a comparatively small heat expenditure.

ACTUAL RESULTS OBTAINED.

It is obviously impossible to draw any exact comparisons between solid and liquid fuels without complete trials carried out in such a way as to show the actual boiler performance, and there are unfortunately no available data which allow of this being done properly from a scientific point of view. Commercially, however, the results have some value, and to make the comparison as useful as possible the corresponding consumption of coal as actually ascertained is given in four cases :—

Name of Ship.	Type Burning Installation.	Consumption per I.H.P. per hour in lbs.	Corresponding Consumption of Coal.	H.S.	I.H.P.
C. F. Laiesz	Körting	1·408	1·93	7,560	2,200
Sithonia	Howden	1·065	1·49	—	2,500
Murex	Rusden-Eeles	1·3 ? 16 tons	25 tons	5,202	—
Syriam	do.	1·32	—	2,480	800
Khodoung	The Author Armstrong, Whitworth & Co.	1·08	1·67	2,700	960

Differences in consumption in favour of liquid fuel as compared with coal :—

C. F. Laiesz	say 27 per cent.
Sithonia	28·6 „
Murex	36 „
Khodoung	35·5 „

All the vessels have triple-expansion engines of normal proportions, except the *Sithonia*, in which quadruple-expansion machinery is fitted, and from the coal consumption trial the amount of water required per i.h.p. must be considerably less than in the other vessels referred to.

SOME EXPERIMENTS ON STEAM-ENGINE ECONOMY.

THE object of this paper, contributed to the Institute of Mechanical Engineers by Professor R. L. Weighton, was to record the results of two separate and distinct sets of experiments bearing upon the economical performance of the steam-engine. The first constitutes a series of experiments made with a view to determine the economical effect of reheating the steam passing through the receiver of a double-expansion or compound engine. The second forms a series of experiments made with a view to determine the influence upon economy of degree of vacuum in the condenser of a triple-expansion engine. Both sets of experiments were made upon the experimental engines in the Engineering Laboratory at the Durham College of Science, Newcastle-upon-Tyne, and form part of a systematic course of research work upon the steam-engine which is being carried out there. The results, in tabular form, are appended :—

RESULTS OF RECEIVER REHEATING TRIALS.

Cylinders $\frac{7'' \text{ and } 15\frac{1}{2}''}{18''}$ Boiler Pressure 200 lbs (above atm.) Jacket Steam off. Cut off in L. P. Cylinder 7″.

Power varied by shifting H.P. Eccentric. Condensing Water adjusted for an approximate Vacuum of 24·4″.

No. of Trial	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
Date of Trial. 1900	May 4	May 4	April 27	April 27.	May 11.	May 11.	May 18.	May 18.	May 25.	May 25.
Reheater Steam.. .. .. off or on	off	on	off	on	off	on	off	on	off	on
Shift of H.P. Eccentric .. ..inches	$-\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{5}{8}$
Pressure in H.P. Steam Chest lbs. above atm.	195·5	194	197	196	198	197	199	198	198	198
Pressure in Reheater Coils „ „ „	0	193	0	194	0	194	0	195	0	195
Pressure in Receiver „ „ „	50	54·3	43	47·5	31	36	16·7	21	1·0	4
Barometer .. .. inches of mercury	29·4	29·4	30	30	29·8	29·8	29·9	29·9	29·75	29·75
Vacuum .. .. „ „ „	23·12	23	24·4	24·37	24·4	24·5	24·42	24·45	24·2	24·4.
Mean Pressure, reduced to L.P. Cylinder lbs. per sq. inch	58·1	60·4	54	55·6	44	46·5	30·8	32·7	12·36	13·78
Revolutions per minute	133·4	136·1	130·2	134.4	132·8	137·6	133·9	137·5	136·4	143·2
Condensation in Receiver ..lbs. per hour	95	49·5	not taken	not taken	81·78	43·96	55·8	32·6	would not drain	would not drain
Condensation in Coils of Reheater.. .. lbs. per hour	0	110	0	106	0	88	0	68	0	22
Total Water used .. lbs. per hour, W.	2298	2454	2050	2216	1725	1896	1270·6	1378·6	599·5	686
Steam shown by Indicator Cards at L.P. cut off in percentage of total water	72	76·7	68·4	75	68·3	77·2	60	70	60·4	71
Indicated Horse Power	131	138·8	118·7	126·2	98·7	107·6	69·7	75	28·5	33·3
Brake Horse Power	120·3	126·1	112·6	117·1	94·1	99·5	63·5	67·7	24·3	27·32
Mechanical Efficiency..	·918	·908	·948	·928	·953	·925	·911	·902	·854	·820
Pounds Water .. .. per I.H.P. hour	17·54	17·61	17·2	17·5	17·5	17·62	18·23	18·38	21 06	20.59
Pounds Water .. .. „ B.H.P. „	19·1	19·46	18·2	18·92	18·33	19·06	20	20·36	24·67	25·11

NOTES.—1. Trials were made in *pairs*—steam *off* and steam *on* Reheater—the one after the other with a sufficient interval.

2. The Brake Sluices were adjusted for the first of each pair, and were not altered for the second trial of the pair.

3. In plotting the results on Fig. 2, Plate 2, the Powers in Nos. I. and II. are brought up to the average vacuum of the others, viz., 24·4 inches.

RESULTS OF VARIABLE VACUUM TRIALS.

Cylinders $\frac{7''\text{-}10\frac{1}{2}''\text{-}15\frac{1}{2}''}{18''}$. Jacket Steam off. Receivers drained continuously.

Cut off in each Cylinder $10\frac{1}{2}''$. Brake Sluices shut 1 inch.

No. of Trial	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Date of Trial. 1902	Mar. 14.	Feb. 28.	Feb. 28.	Feb. 28.	Mar. 7.	Feb. 21.	Feb. 21.	Feb. 21.	Feb. 21.
Vacuum—inches of mercury	0	11·53	16·70	19·69	20·40	21·79	24·07	25·72	28·18
$\frac{\text{Condensing Water}}{\text{Feed Water}}$	—	5·7	7·0	8·4	8·3	8·7	11·2	15·3	43·7
Barometer	29·7	29·15	29·15	29·15	29·7	29·85	29·85	29·85	29·85
Pressure in H.P. Steam Chest (above atm.)	147	146	147	148	147	151	150	148	149
Revolutions per minute. (R)	109	118·6	122·6	124·5	124·3	125·4	126·6	127	127
Indicated Horse Power	54·7	70·2	76·9	78·7	78·5	81	83	82·2	83·4
Brake Horse Power	48·3	60·3	64·9	67·4	66·9	69·1	70·6	71·1	71·5
Mechanical Efficiency	·882	·859	·844	·856	·852	·853	·850	·865	·857
Total Water used per hour in pounds. (W)	1048	1141·5	1189·5	1210	1218	1217	1235	1246	1247
Hotwell Temperature °Fahr. (t_H)	212	193	177	164·5	164·3	157	142·8	129·2	88·8
Mean Pressure reduced to Low-pressure Cylinder (M)	29·75	35·06	37·13	37·41	37·33	38·22	38·85	38·32	38·85
I.H.P. at 120 Revolutions. (I)	60·3	71	75·2	75·8	75·7	77·5	78 7	77·6	78·8
B.H.P. at 120 Revolutions. (E)	53·2	61	63·5	65	64·6	66·1	67	67·2	67·6
Water per Hour at 120 Revolutions. $(W_1) = \frac{120\,W}{R}$	1154	1155	1164	1166	1175	1164	1170	1177	1178
Heat Units per Hour at 120 Revolutions.* $(W_H =) \frac{W_1 (T_1 - t_H)}{T_1}$	954	973	996	1008	1016	1015	1033	1053	1092

* T_1 = Total heat—above zero Fahr.—per lb. of steam of boiler pressure. (W_H) = Heat units reduced to lbs. of water for comparison.

RUSSIAN RAILWAY ENTERPRISE IN CENTRAL ASIA.

THE *Monthly Review* for August contains an able article from the pen of Mr. R. E. C. Long, on the new railway which the Russian Government have decided to construct between Orenburg, an important town in South-East Russia, and Tashkend, the centre of the most fertile district of Central Asia, situate about 300 miles from the Afghan frontier. The writer points out that the importance of this new project has been somewhat overlooked in England, and describes its political significance as of far greater moment to British interests than the recently completed trunk line which has linked Port Arthur with the capital of the Empire.

The new railway follows the natural and historic path of advance in Central Asia, keeping closely almost for its whole length to the still-existing track which before the opening of the Transcaspian line was the main artery of trade. The only considerable engineering difficulty met with is the bridging of the Ural River at the beginning of the line. From Orenburg the line runs east to Orsk, and there turns to the south, running between two outlying spurs of the Urals, through the Kirghiz country to Irghiz. At Irghiz is crossed a branch of the Turgai River, and thence the railway runs along the road to Kazalinsk on the Sir Daria, actually touching the north-east coast of the Sea of Aral. At Perovsk the line diverges eastward from the road, touching it again by a southward bend at Fort Julek, after which it runs straight to the town of Turkestan. . . . No part of the country traversed, except the last part, is very fertile. But the railway will not only bring supplies both to and from the districts through which it lies, but it will also tap the whole fertile valley of the Oxus; goods sent from the Oxus valley being put upon the railway where the line touches the north-eastern coast of the Sea of Aral. The railway will, therefore, facilitate communication with Khiva and the Oxus valley, as well as with the Sir Daria valley and Ferghana.

It appears that there was an alternative route proposed for the new railway through Central Asia, which was only finally abandoned in 1900. It was to have started from Saratov, on the Volga, running in a direct line across the Caspian depression and the Ust-Yurt plateau to Kungrad and Khiva, and thence as far as Chardjui. Though this latter project would undoubtedly have solved the problem of intercommunication as well as the present line, there were many advantages peculiar to the Tashkend route which could not be neglected. It will be safe from the attacks of the semi-subdued tribesmen, and presents none of those difficulties in regard to water-supply and protection from sand which would have been met with in the desert south-east of Saratov.

But perhaps the greatest advantage of the new line lies in the fact that it will provide, although not by a very direct route, intercommunication between Central Asia and Siberia. . . . . At the present time it is practically impossible to transport the surplus Siberian products—grain, dairy produce, and timber—into Central Asia. Siberian products must first be sent several thousand miles by railway to Samara, after which follow a second journey of a thousand miles down the Volga, a sea voyage across the Caspian Sea, and a fourth journey of a thousand miles along the Transcaspian railway.

It is expected that the new line will especially stimulate the cotton-growing industry in Central Asia, which has hitherto failed to find room for expansion owing to the difficulties of transport just referred to. In this lies the chief commercial hope of Russia's new undertaking.

The culture of cotton in Central Asia within recent years, and particularly since the introduction of the American plant, has attained enormous dimensions. During the last sixteen years the area devoted to cotton has increased from 1,200 to 375,000 acres, and in 1900 Russia received from her own possessions 7,500,000 bales, or nearly half the amount required for the home manufactures. . . . Cotton, moreover, is one of the few manufactures in which Russia is likely to compete with Western Europe in foreign markets, and an increase in the quantity of cheap material available would probably result in such a development of the manufactures as would drive all competition out of China and Persia.

Mr. Long regards the new railway as likely to be procreative of many important developments, among which the first would probably be branch lines into Eastern Turkestan and Western China.

The English commercial interest in the railway, however, will only begin when the inevitable connection with Indian railways is accomplished. It is hardly to be expected that the Indian authorities will continue for ever to suffer from the blind panic which prevents them welcoming a measure approved of by nearly every authority who has not been blinded by Russophobist dread. The Channel Tunnel (in essence a very similar project . .) was killed by insular panic ; but it is safe to say that had any other nation been concerned, Englishmen would have been the first to turn into ridicule such a dog-in-the-manger policy. . . . It is obvious, also, that if the Russians are intent upon attacking us in India, their plans must be on such a vast scale that the contemporaneous laying of a military railway will be but a detail.

After discussing the strategical value to the Russians of a possible through communication between Moscow and our Indian Empire as a means of invasion, the writer concludes :—

Friendship with Russia can be established and confirmed only on the basis of an adjustment of the mutual relations of the two Powers, without regard to the shifting play of hatred and amity which goes on all over the rest of Europe. The creation of the railway from Central Russia to the Afghan and Indian frontiers is a factor in these mutual relations which needs adjustment, and whether it means bad relations springing from apprehension, or good relations based upon an understanding, depends upon ourselves alone.

THE PANAMA CANAL.

ITS COMMERCIAL VALUE TO THE UNITED STATES.

MR. BENJAMIN TAYLOR contributes to the *Monthly Review* an article on the Panama Canal, entitled "The Wedding of the Oceans." He emphasises the fact that the Suez Canal offers no basis of comparison to those who would accurately forecast the future of the new canal.

The canal will doubtless be of more strategical value to the United States than of commercial value to any of the nations ; but it will also be of more commercial value to the United States than to any other nation. Whether it will be of any great commercial value to Great Britain, or whether we shall derive any benefit at all from it except in the general enlargement of the world's commerce may be open to doubt. In its commercial aspects a canal across Central America, at any point, is strongly differentiated from the one across Suez. The Suez waterway connects two vast and thickly populated land areas ; the Panama Canal will connect two wide oceans. East of Suez are the teeming millions of Asia, waiting with their produce for the markets of Europe ; west of Suez are the workshops of the world. East of Panama is the broad Atlantic, separating the canal from the workshops and markets of Europe ; west of it are 6,000 miles of ocean, sprinkled with a few unconsidered insular trifles. Those who attempt to deduce from the experience of Suez a forecast of the future of Panama cannot fail to get far astray. There is no basis for comparison, even with a canal through Nicaragua, which would have passed through a region capable of development and of furnishing some local traffic.

WHERE THE UNITED STATES WILL SERVE.

He thus summarises its value to the United States :—

But in the case of the American canal, if, instead of looking east and west, we look north and south, a different prospect presents itself. The waterway will connect the busy workshops of the Eastern States of North America with the hobbledehoyish, but potentially industrious, Republics of the western side of South America. It will also connect the Pacific States of North America with the Eastern Republics of South America, though it is doubtful if much interchange of traffic will result. California and Argentina are competing wheat and meat producers, and neither country has much else that the other wants. The main point is that the commercial wants of the western side of South America are at present almost exclusively supplied from Europe ; in future they will probably be supplied from the United States, when the canal brings them a few thousand miles nearer together. Again, it is expected, and with some show of reason, that when the canal is completed every pound of cotton required by the growing industries of Japan will be supplied from the Southern States of the American Union. And there can be little doubt that the coal of West Virginia and the iron of the Southern States will have opened up to them wide markets from which they are at present shut out.

ITS BENEFIT TO BRITISH TRADE.

This, says Mr. Taylor, is problematic:—

The extent, as we say, to which British trade will benefit by the canal is very problematic. For Europe generally the gain will be a nearer route to the Pacific shores of North and South America, to the South Sea Islands, and to New Zealand. To Canada the canal will ultimately be of first-rate importance when she is more industrially developed. At present, however, her exports are mainly agricultural, and find their market almost entirely in the United Kingdom or the United States.

The reduction in distances is all in favour of the United States; but the change in many instances produces a complete reversal of the advantage which British trade at present enjoys. By the Suez Canal England is closer than the United States to Australia, China, and Japan by about 2,700 miles. When the American canal is built, the cities of the Atlantic seaboard of North America will be only 1,000 miles farther than this country from Hong-Kong and Central China; and they will be upwards of 1,200 miles nearer the northern ports of China, Korea, and Japan, 2,700 miles nearer to the western ports of South America, 1,300 miles nearer to Melbourne, and more than 3,000 miles nearer to New Zealand. The Atlantic termini of the Nicaragua and Panama Canals are about 300 miles apart, but are about the same distance from New York. For certain ports each route is shorter than the other, but for the traffic as a whole the difference in sailing distances is unimportant.

Although it is not too much to predict that the whole world will benefit by the opening of the canal, the present writer adheres to the opinion he has before expressed, that the commercial value of such a waterway has been exaggerated.

THE NAVY AND THE ENGINEER.

THE condition of the engineering branch of the Naval service is the subject of a further article in the *Monthly Review* for August. Mr. Carlyon Bellairs, whose defence of the Admiralty's position appeared in the May number of that journal, has again taken up the cudgels in reply to Mr. D. B. Morison's vigorous answer to Mr. Arnold Forster's statements in the House of Commons during the debate on the Naval Estimates. This second article, however, is a long way behind the one that appeared in June, and may be said to be somewhat weak and inconclusive.

The following excerpts will give our readers an idea of the strain in which the article is written:—

It is regrettable to find, in the threatening language used by the civil engineering associations, indications that what is sought is the power of enforcing advice, to be exercised by men partially acquainted with the internal economy of a navy, and who have no idea of the relations of their special sphere to the whole.

It is evident that engineers think too much on the surface, or they would not argue that a mistake here and there is a sufficient cause for revolutionising the system under which the Navy has always been governed. The bias of the mechanical mind is that, dealing with easily ascertainable causes and effects, formula and routine methods, it believes that all difficulties are capable of solution with mechanical precision. Then, when argument fails, discredit is thrown on the Admiralty, and Lord Selborne is represented as a puppet.

The engineer is received into the wardroom on his own merits. If here and there, as is the case with military officers, the social status is beneath that of other officers, and it is necessary to make it equal, the nomination system must be introduced, as in the executive and accountant branches. There will be no lack of desirable candidates if a better balance between the lower and higher grades is effected by the reduction of the number of entries and the substitution for watch-keeping duties of the artificer-engineers.

The note at the end of the article is probably the most interesting. It runs as follows:—

A strong contention has been put forward that the number of engineer officers on board British ships is dangerously insufficient. It is, unfortunately, impossible to give comparative figures of artificers, but the following figures in parentheses give the number of engineer officers in typical ships in the principal navies: British battleships, *Renown* (7), *Ramillies* (8), *Canopus* (7, exclusive of an inspector of machinery for service with the fleet), *Cæsar* (6); French battleships, *Saint-Louis*, *Charlemagne*, *Gaulois*, *Bouvet*, and *Jauréguiberry* (4 engineer officers each). The German *Wittelsbach* (5); the Russian *Poltava* (7); and the American *Wisconsin* (5). Turning to typical first-class cruisers, the numbers are: British, *Kent* (7); French, *Gueydon* (4); German, *Furst Bismarck*, (4); Russian, *Bayan* (6); and American, *Brooklyn* (5). I think that these figures must give pause to the civil engineering agitators who so often expose themselves to such complete refutation as to induce the belief that they are the bad workmen of their profession, for they start cutting without feeling the edge of their tools.

REVIEW OF LEADING CONTINENTAL PAPERS.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of the Continent.

IRON METALLURGY AT THE DÜSSELDORF EXHIBITION.

THE Düsseldorf Exhibition is so much the more interesting and remarkable as it represents the industry of only two German provinces, the Rhine and Westphalia, with neighbouring districts; but at the same time it must be borne in mind that these two provinces contribute a very important contingent to the German production of pig iron and finished iron and steel. As German ironmasters did not obtain sufficient space at the Paris Exhibition of 1900 to make a display worthy of their industry, they preferred to reserve their forces for that now being held at Düsseldorf; and they have succeeded beyond all possible expectation. These remarks are made by M. Alexandre Gouvy, formerly manager of the Alais Ironworks, and subsequently of some steelworks in Russia, who has made a profound study of the metallurgical exhibits. He has recorded the results of his observations in an exhaustive communication to the *Société des Ingénieurs Civils de France*, and has made an abstract of the same for the *Association des Ingénieurs de Liége*, from which a few salient points are here noted.

KRUPP PAVILION.

The first steam engine erected at the Krupp Works finds a place by the side of the most powerful modern engines, an armour-plate weighing 106 tons, a hollow lay shaft, 45 metres (147½ ft.) long, weighing 52 tons, and the most varied steel castings, including some of extra hard quality. A railway waggon made of pressed steel has a carrying capacity of 40 tons for a dead weight of only 13·6 tons; and the roll-train that turned out the 106-ton armour plate has rolls 4 metres (13 ft.) long.

HOERDE PAVILION.

The chief exhibits of this company are spare shafts for the 500-horse Oechelhäuser and 1,000-horse Otto-Deutz gas engines for the electric generating station at the works; a plate weighing 9·8 tons and another weighing 8·15 tons; a rail, 76 metres (250 ft.) long, weighing 3·116 tons, that forms a hand-rail in the middle of the pavilion; steel castings, with very hard surface made by the Hunt process with rotary moulds, and pressed plates for the frames of waggons and locomotives.

THE BOCHUMER VEREIN

shows crucible cast-steel bells; an enormous cast-steel stern post for a twin-screw steamer, 15 metres (49 ft.) high and weighing 87 tons; a converter ring weighing 18 tons; a partially finished cast-steel cylinder for a 5,000-ton hydraulic press, absolutely free from blow-holes although weighing 34 tons; cast-steel locomotive wheels, and the crank-shaft of a 1,500-horse gas engine.

THE EHRHARDT PAVILION

is chiefly distinguished for the large cylinders rolled without weld at Reisholz by a special method, which Herr Ehrhardt has only brought to perfection after long and costly trials. The parts are shown in the various phases of manufacture, from the ingot pierced and drawn out under the hydraulic press to the finished cylinders rolled in a special train, with the upper roll oscillating and adjustable during the operation. In this manner cylindrical bodies are formed 3·5 metres (11½ ft.) long, and having a diameter of more than 2 metres (6 ft. 6¾ in.).

THE GUTEHOFFNUNGSHUTTE, OBERHAUSEN,

exhibits a 1,000-horse four-cylinder Otto gas-motor, driving, by a prolongation of the fly-wheel shaft, two air cylinders fitted with Corliss inlet valves and Stumpf delivery valves, these blowing cylinders having been installed by the engineers of the Oberhausen Works, where a great many Otto engines have for a long time been working with blast-furnace gas.

THE MACHINE HALL

contains a most interesting collection of iron-works appliances, especially motors for working with blast-furnace gas, although at the exhibition this is replaced by producer gas, the types represented being—

1. The 700-horse two-period Oechelhäuser motor, driving a blowing cylinder that draws in 500 cubic metres (17,658 cubic feet) of air at 100 revolutions per minute, and delivers it at a pressure of 0·54 kilogrammes per square centimetre (7½ lbs. per square inch). This motor is distinguished by having two pistons arranged back to back in one and the same cylinder, without special parts for admission or delivery, the pistons themselves uncovering the orifices; but, on the other hand, the mixture of air and gas is effected by a special compressor, the contrary motion of the pistons requiring a fly-wheel shaft with three cranks.

2. The 500-horse two-period Körting motor, which also works a blowing cylinder for 500 cubic metres (17,658 cubic feet) of air at 100 revolutions per minute, delivering it at a pressure of 0·4 kilogramme per square centimetre (5½ lbs. per square inch), this cylinder being fitted with Corliss inlet and Stumpf delivery valves.

3. A second Körting motor of 700 h.p., driving a three-high roll-train for medium size rails, this being the first rolling-mill that has been made to work by a gas engine. The Körting motor is that which of all gas engines most nearly resembles the steam engine in general appearance, the gas and air compressors (arranged laterally) having the appearance of the cylindrical slide-valves of an ordinary engine. There are only valves for the admission, the exhaust being effected by orifices uncovered by the piston. This double acting piston, working in a single cylinder closed at both ends, would cause difficulty with unpurified gas. This however, is obviated by its purification.

4. Louis Soest and Co. show a 300-horse four-period motor, which has been designed to turn to account the experience gained with other motors. While all the parts are easily replaced, wear is reduced to a minimum and all the working parts are kept cool.

COLLECTIVE MINE EXHIBITION.

Here may be found self-charging boilers, a Weiss central condensation arrangement, a Tigler briquette press at work, and also various fans and pumps. The large Haniel and Lueg underground pumping engine is designed to raise 25 cubic metres (5,500 gallons) per minute to the height of 500 metres (1,640 ft.). Opposite the large Humboldt-Kalk headgear is an original winding engine, with vertical compound cylinders, the pistons of which work, by rods and triangular levers, two conical half-drums; and near it is a compact electrical winding engine, capable of raising a useful load of 4·2 tons at a speed of 20 metres (65½ ft.) per second.

WIRELESS TELEGRAPHY.

THE problem to be solved is thus stated by M. Victor Thiran: To send through space, by means of a small transmitter, signals that can be received at the greatest possible distance by suitable apparatus, without the sending and receiving stations being connected in any manner; and he divides the attempts made to solve this problem into four categories, in relation to the experiments which have been made with sonorous, luminous, electro-magnetic or electric waves, passing rapidly over the first three, but dealing at greater length with the solution by electric waves, which alone appear calculated to afford a complete solution of the problem.

After recounting to the *Society of Hainaut Engineers* the experiments of Hertz, Popoff, and Marconi, the author described those with very compact appliances by M. Ducretet, of Paris, whose signals, sent from the Eiffel Tower to the Panthéon, a distance of 4 kilometres (2½ miles), were received with perfect distinctness. In Belgium conclusive experiments were made between La Panne and the mail steamer *Princess Clémentine*, for a distance of 80 kilometres

(50 miles); and messages sent from Brussels were received accurately at Malines, or Mechlin, while those in the reverse direction were indistinct, owing, it is supposed, to the masses of metal at the receiving station, the Colonne du Congrès, as indeed was also the case with the return messages sent from the Panthéon to the Eiffel Tower.

Notwithstanding the important results obtained, several gaps still remain to be filled. The transmitting instrument sent signals in all directions, each one of which could receive them; and in the event of there being several stations along a given radius, all the signals mingled and became confused. Moreover, it is evident that, for extending the distances to be traversed, the length of the antennæ cannot be increased indefinitely, any more than can the power of the coils employed. Accordingly, a legion of inventors endeavoured to realise these various improvements, and proposed a great many methods; but those that have been subjected to practical trials are for the most part founded on the principle of "syntonisation," *i.e.*, imitating the acoustic phenomenon of resonance.

Marconi has succeeded in greatly reducing the height of the antennæ necessary, and has transmitted signals to a distance of 50 kilometres (31 miles), with antennæ consisting of hollow cylinders, only 1·25 metres (4 ft.) high and 40 centimetres (15¾ in.) in diameter. His experiments also tend to prove that he is very near solving the problem of syntonisation. By electrically "tuning" his transmitting and receiving instruments so that the latter can only be influenced for waves of determined length, and solely by them, he has succeeded in operating ten transmitters connected with one and the same antenna, each sending its message to one only of ten receptors placed side by side, and also utilising a single receiving antenna.

According to Guarini and Poincarré, this system is incomplete, because Thomson's formula, on which it is founded, applies only to the principal oscillation, taking no account of secondary oscillations, the effects of which may be felt to a distance of 20 kilometres (12½ miles). With this system multiple and simultaneous telegraphy would be impossible in both directions, because the receiving instruments must be at least 20 kilometres (12½ miles) apart, in order not to be influenced by the corresponding transmitter.

Guarini endeavours to ensure the secrecy of a message in a manner different from that of Thomson. The electric waves emitted by the antenna of the transmitting station radiate normally to its surface and in all directions. By means of a longitudinal slit in the metal sheath of a carefully insulated wire, Guarini restricts the electric radiations to a narrow pencil, or series, which he transmits to the receiving antennæ, so arranged as to receive none but the radiations emitted by the transmitting station; but it is evident that all the stations comprised in the direction of the pencil, or series, can receive the messages intended for another station.

The Slaby-Arco system, which enjoys a certain amount of favour in several countries, differs from that of Marconi in the connections of the antennæ. In the latter system there is an open circuit between the top of an antenna and the earth, while in the Slaby-Arco system the circuit is closed by the earth, since the summits of the transmitting and receiving antennæ are in communication with the soil; and in addition the Slaby antenna is constituted by a mass of metal wires.

In fine, the progress made since the first practical attempts at wireless telegraphy in 1897 has been enormous; and the author concludes that electric waves will before long form an invisible network of vibrations round the world.

GOLD IN THE SALONIKI REGION.

Of all the regions in European Turkey, certainly that of Saloniki most interests the geologist, while recalling the grand phenomena of past ages. The glacial period here exerted intense influence; and there are few hills or mountains that do not bear ineffaceable evidence of the passage of the "grands laboureurs," while the insignificance of the erosive phenomena has preserved this evidence almost intact from the most remote period to the present day. No vegetation interferes with geological research, and no violent erosion suggests a wavering of the judgment, while the glacial deposits have scarcely suffered the ravages of time. The few streams which flow through them have simply worn a shallow bed, the banks of which, generally vertical, permit of easily studying the nature and intimate constitution of the deposits.

Thus opens a communication to the *Société de l'Industrie Minérale* on the glacial formations and auriferous deposits of the Saloniki region, by M. François Blanc, who observes that it will be readily understood how interesting is a geological study under such conditions, very rare in Europe, where erosion daily pursues its work of destruction. In the Saloniki region the erosive phenomena characterising epochs later than, or contemporary with, the glacial period have suddenly ceased; and since the most remote times the streams have but little worn away their banks. The region under notice may be regarded as a vast circle of about 100 kilometres (62 miles) diameter, bounded by high mountains, but open to the sea on two sides—to the south-west on the Gulf of Saloniki, and to the south-east on that of Orfanio.

GEOLOGICAL DESCRIPTION.

The primitive rocks (gneiss, schist, and mica-schist) predominate, constituting all the mountain masses. At no point have there been found to exist sedimentary deposits anterior to the tertiary epoch, except, perhaps, at Makukovo, where carbonaceous shales and sandstones may be perceived at places in the beds of the streams, overlain by deposits of glacial origin. The chief eruptive rocks are the peridotites, which make their appearance at several points, especially along a well-determined line; and a considerable trachytic peak has been noticed at Dohantza.

It is very remarkable that limestone has not been found in the Karadagh mass; and to this exceptional fact is due the possibility of reconstituting the successive periods of the glacial invasion which at a given moment covered the region. Another no less remarkable fact is that all the alluvia, or deposits of whatever nature, issuing from the Karadagh are auriferous, whence it happens that, whenever alluvia or deposits free from calcareous elements occur in the Saloniki region, there is a certainty of their being auriferous. These two facts confirm one another, and have permitted of synthetically studying the geology of a whole region, if this expression be permissible; and, indeed, they permit at points even far distant of characterising the origin of alluvia and of tracing them to their source. Such a study is possible under these circumstances, and will permit of reconstituting, from their track or the *débris* evidencing their passage, the ravages of the "great ploughmen."

THE GLACIAL DEPOSITS.

It may be said generally that in the circus comprised within the Rivers Vardar and Karasou, the Gulf of Saloniki and the Kortiatch chain, deposits of glacial origin cover all the points where primitive rocks do not crop out; and these deposits chiefly occur in the western portion of the circus, the middle being almost entirely free from them. In the Klkch region their intensity is such as to escape all analysis, only permitting the casual observer to form uncertain hypotheses as to their origin; and to find them with their true characteristics they must be studied in the immediate neighbourhood of Saloniki. A study of the different glacial deposits in this neighbourhood has led the author to assign them a common origin, and has demonstrated the existence, at the glacial epoch, of an immense glacier which came into contact with the Kortiatch chain and passed it at all the indentations, thus sending numerous ramifications into the present plain of Saloniki.

AURIFEROUS DEPOSITS.

It may be said that, as a rule, in the whole perimeter comprised between the Rivers Vardar, Karasou, and its tributary, the Boutkova, and the Langaza depression, there is not a stream that does not carry down gold-bearing sand. In these regions gold occurs in the form of dust and also of nuggets; but the latter are only found at certain points, while their weight has never been known to exceed 20 grammes (⅔ oz.). As to the dust, which constitutes the greater portion of the gold collected by the inhabitants, it is very fine, readily floating in the cradles, and thus rendering even an approximate estimation of the richness of the sand especially difficult.

Nor does washing with the sluice afford any better indication. Owing to the large quantity of magnetite in the sand, the spaces at the bottom of the sluice, where the gold should accumulate, are soon filled up; and, when this takes place, the tenuity of the gold does not permit it to lodge there free from the action of the current. It thus happens that a sample weighing a ton shows scarcely any more gold than does one of 2 cwt.; and this circumstance explains the fact that the gold wealth of many rivers is approximately the same over the whole length of their courses.

There is also little certainty as to the gold content in the alluvium constituting the high terraces. Some analyses have shown 5 grammes (⅙ oz.) to the ton; but it is more probable that the real content does not attain half that figure. Considering the enormous extent of the alluvia, their slight cohesion, and their uniformity as regards richness, such a content may permit of remunerative working; but the treatment must be appropriate to the physical state of the gold. Methodical prospecting may also afford the chance of finding rich places in the region of the Karadagh, nuggets of 20 grammes (⅔ oz.) having been found at various points. To be of any use, explorations should be carried to a certain depth, because the presence of old workings leaves little chance of finding virgin alluvia at all rich near the surface. On the whole, concludes M. Blanc, the whole region of the Karadagh affords a vast field of exploration to future prospectors.

NEW EJECTO-CONDENSER.

INVENTED by Alexander Morton, of Glasgow, in 1867, nine years after the Giffard injector, of which they are a generalisation, the ejecto-condensers were perfected and brought out chiefly by the Brothers Körting. In these appliances the motive fluid, steam, arrives by an annular pipe surrounding the induced jet of water; and Professor Boulvin describes them as Giffard injectors taking their motive steam from the cylinder and delivering at atmospheric pressure.

As explained to the *Société de L'Industrie Minérale* by Professor Rateau, his ejecto-condenser consists, like the others, of three distinct parts, viz., (1) the convergent nozzles, by which arrive the two fluid currents, one of them, annular, surrounding the other; (2) the mixer, in which the steam, outside the water, becomes condensed on contact with the water, with a considerable change in the mean specific weight of the fluids; and (3) the divergent diffuser, in which the speed of the whole current issuing from the mixer is reduced and partially transformed into useful pressure, the diffuser being connected with the mixer by a throttled section called, by the inventor, the neck.

CHARACTERISTICS OF THE NEW FORM.

The new ejecto-condenser is characterised by (1) its injection pipe, which gives the jet a special form, ensuring rapid condensation of the steam; (2) a regulating of the water volume; and (3) a special arrangement of retaining valve. The injection pipe, a cross section of which has the appearance of a star with several rays, delivers a jet of water divided into thin sheets, the perimeter of which is about three times that of the full circular jet corresponding with the same volume. The special regulating arrangement permits of varying the water volume in accordance with the power of the engine, whereas in all previous injecto-condensers the expenditure of water is constant whatever be the quantity of steam. The retaining valve, which is hollow and bi-conical, prevents the water from entering the cylinder during stoppages.

THE THEORY OF EJECTO-CONDENSERS

is founded on the theorem of conservation of the quantities of motion during the shock of the two fluid currents in the mixer; and then, for estimating the pressure which the *vis viva* can overcome in the divergent diffuser, account must be taken, on the one hand, of loss by friction and eddying in this portion of the appliance, and on the other hand of the effects produced by the induced air and the steam, the condensation of which may not be complete when the fluid current leaves the mixer to enter the diffuser.

INFLUENCE OF AIR AND NON-CONDENSED STEAM.

The air which penetrates into ejecto-condensers greatly interferes with their working, as it occasions a reduction in the height of pressure that they can afford, and also a diminution in the vacuum, which would otherwise be perfect. This air proceeds partly from the condensation water, which dissolves about 1·7 per cent. of its volume at ordinary temperatures, but also, and especially, from the exhaust steam, because it is contained in the water for feeding the boilers; and air also enters by the stuffing-boxes and slide-valves, and at the pipe joints, so that at least 4 per cent. must be allowed for it altogether. To the disadvantageous action of the air is also added that of the uncondensed steam; and there is reason to suppose that the steam is not entirely condensed when the fluid current traverses the neck of the appliance. The proportion of uncondensed steam is evidently so much greater as there is more air to interfere with the condensation, and less difference between the temperature of the steam and that of the water on leaving the mixer.

GENERAL LAW.

An experimental determination of this difference leads to results which permit the author to formulate the following simple and remarkable law: For an appliance working under determined conditions of water pressure above and below (up-stream and down-stream), the difference in temperature between the steam and the water is practically constant, whatever be the volume of steam expended.

COMPARISON BETWEEN THE RATEAU AND OTHER EJECTO-CONDENSERS.

A comparison of the curve representing the vacuum obtained by the new ejecto-condenser with that by the condenser of a Corliss engine at the Creusot Works shows that the former appliance affords practically the same degree of vacuum, but that beyond 30 deg. Cent. (86 deg. Fahr.), and as the temperature increases, it becomes more and more inferior. At ordinary temperatures of working, however—*i.e.*, between 30 deg. and 35 deg. Cent. (mean 90 deg. Fahr.), —the difference is slight, being only about 27 millimetres ($1\frac{3}{32}$ in. of mercury). For an equal expenditure of condensation water, therefore, ejecto-condensers afford, under normal conditions, a vacuum practically equal, or at any rate but little inferior, to that obtained with good ordinary condensers.

APPLICATIONS AND ADVANTAGES OF THE EJECTO-CONDENSER.

Although ejecto-condensers may be placed in any position, the vertical arrangement is best, because it favours the action of gravity. They may be applied to any type of engine, especially those running at a high speed. Their chief advantages are simplicity, slight first cost, small space occupied, and especially the absence of delicate parts, so that they cannot get out of order, while they require no attention. Perfect regularity of working may be secured by avoiding the entrance of air and by forcing water into the appliance if it be not under pressure, or by hanging the ejecto a few metres above an evacuation basin, filled with water by natural flow or by a centrifugal pump.

Owing to their simplicity, ejecto-condensers may easily be fitted to small steam engines, even those of 10 to 15 h.p.; and at the same time there is no difficulty in extending their use to large engines, because they are capable of dealing with as much as 20 tons of steam per hour. They are therefore, equally with injection or surface condensers, suitable for the central condensation plants of works and mines; and a single ejecto-condenser will in most cases suffice to deal with the steam of an ordinary pit.

Winding engines and those driving roll-trains stop every minute or every two minutes, when steam admission and exhaust cease; and, when the engines are started again, they discharge a large quantity of steam. Such variations in the exhaust are met perfectly well by ejecto-condensers with water under pressure or a suction pipe; but there must be a constant volume of water, corresponding with that of steam at the maximum, and therefore far greater than that merely necessary for the mean.

It is true that this difficulty may be overcome by adopting M. Rateau's method of automatically regulating the water injection and shutting off the admission during stoppage; but the volume cannot well be reduced by more than half, so that it is preferable to employ his steam accumulator, which, interposed between engine and condenser, transforms the intermittent flow of steam into a continuous flow, and thus permits of determining the volume of condensation water. This simple appliance consists of a cylindrical plate-iron receiver, in which are piled shallow cast-iron basins, for dividing the water into thin sheets; and this accumulator, a veritable calorific fly-wheel, acts as a condenser when it receives a large mass of steam, but as a generator when the engine stops, the alternate condensation and vaporisation corresponding with slight variations of pressure.

Although, concludes Professor Rateau, this combination of the accumulator with the ejecto-condenser satisfactorily solves the problem of condensation for engines working intermittently, it does not afford the perfect combination which he recommends. There is a fourth element which should be introduced between the accumulator and the condenser, viz., the low-pressure steam turbine driving an electric generator; and then will be realised the complete series—boiler, engine, accumulator, low-pressure turbine and condenser, affording the best possible utilisation of the energy afforded by a given volume of steam.

NEW INTENSIVE FURNACE.

IN all existing furnaces the walls and arched roof are smooth, which the Baron Fernand Del Marmol considers a mistake. In November last he brought a model of his new arrangement before the *Liége Engineers' Association;* and during the present year the system has been tried on a large scale, applied to glass and steel melting furnaces, with a theoretical increase of 60 per cent. in the production, though the inventor is satisfied with claiming 20 per cent.

With the present smooth surfaces, the gases of combustion follow them in a parallel direction without mingling; but if the surfaces be made irregular, like a honeycomb, the gases, entering the cavities and then leaving them through the effect of the draught, while taking a diagonal direction, will come into contact with the gases from the middle of the furnace, multiplying the points of contact, favouring combustion and producing a more intense heat with the same quantity of coal.

These irregular surfaces are produced by setting in (or back) every other brick to the extent of half a brick, or by building out (forward) every two or more bricks, so as to produce a checkerwork, which proceeds quite as quickly as the ordinary form of brickwork, and may be executed as cheaply, no matter what be the nature of the furnace.

RESULTS.

It was stated to the Charleroi section of the above-named association that, with a small trial furnace on the new system for melting glass, fusion was effected in from two and a half to three hours, against nine to ten hours in a similar furnace with smooth sides; and in a large steel-melting furnace ingots were treated more rapidly, the high temperature being practically uniform over all the second half of the furnace.

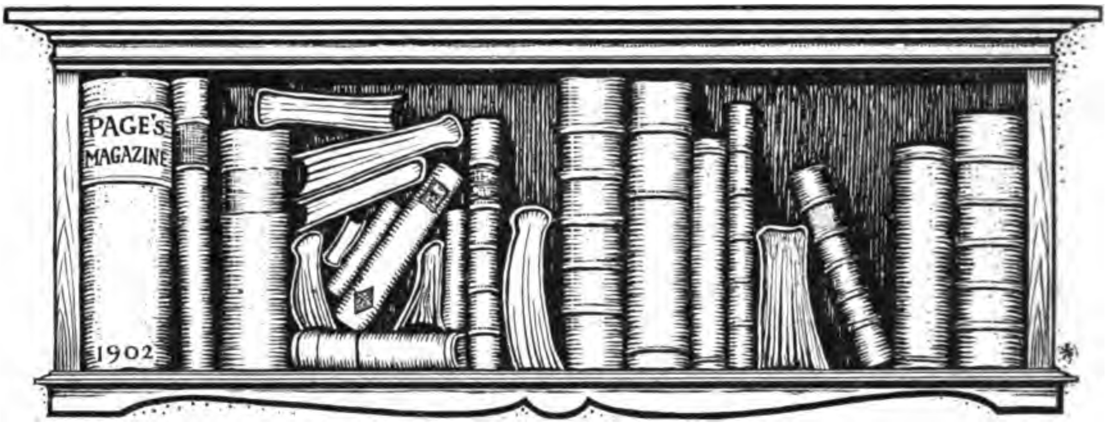
MAINTAINING THE AIR CUSHION IN STEAM PUMPS.

INSPIRED by the Piron hydraulic ram, M. Thiran succeeded in introducing air into the air-vessel of a Tangye steam pump provided with no mechanism for that purpose; and the following description of his arrangement is contained in a paper to the *Société des Ingénieurs du Hainaut.*

A small vertical cylinder attached to the air-vessel is surmounted by two valves, one for drawing in air and the other for delivering it into the air-vessel. The bottom of the cylinder is connected by a pipe with the steam pump in such a manner that it can be influenced by the inlet and delivery valves of the latter.

As the water in the small vertical cylinder forms a piston, when the pump draws in water the lever falls in the small cylinder, the air entering by its inlet valve; and, at the return stroke of the plunger, the air drawn in is forced into the air-vessel through the delivery valve of the small cylinder and the pipe connecting it with the air-vessel. In fact, when the delivery valve opens the same pressure is exerted on the water in the air-vessel and that in the small cylinder, the equilibrium that has a tendency to set itself up between the two levels having the effect of forcing air from the small cylinder into the air-vessel. A small plug-cock, between the bottom of the small cylinder and the pipe connecting it with the pump, permits of regulating as may be desired the quantity of air to be introduced, by accelerating or retarding the motion of water in the cylinder.

Before the adoption of this arrangement all the joints in the delivery pipe of the pump, for a length of 300 metres (984 ft.) gave out each time the pump was started; but since the appliance has been added the joints have lasted the usual time, while the arrangement has the advantage of being simple, inexpensive, and applicable to any pump.



BOOKS OF THE MONTH.

In this department special attention will be paid to all books dealing entirely or in part with subjects within the *purview of the Magazine*. While space will be given for expressions of opinion on books or papers of general interest which may be submitted for that purpose, contributors will please remember that this column is intended in the main for reviews of technical books dealing with the Engineering, Electrical, Shipbuilding, Iron and Steel, Mining, and Allied Industries. The address of the publisher and prices should be enclosed in all publications sent for review.

"AMERICAN INDUSTRIAL CONDITIONS AND COMPETITION."

Reports of the Commissioners appointed by the British Iron Trade Association to enquire into the Iron, Steel, and allied industries of the United States. Edited by J. Stephen Jeans. London: Offices of the British Iron Trade Association, 165, Strand, London, W.C.

SOME time ago the British Iron Trade Association decided to send out a Commission to report on the industrial conditions in, and competition from, the United States. The Commissioners included Mr. Axel Sahlin, who reports on pig-iron manufacture; Mr. Enoch James, who takes up general steel works practice; and Mr. E. Parkes, M.P., who deals with sheet and bar-mill practice. The economic and industrial section has been undertaken by Mr. J. Stephen Jeans, who also edits the volume.

It is obviously impossible in a short review to do justice to a volume which extends to some 600 pages, and contains so many maps, diagrams, and illustrations. It may at once be said, however, that it is by far the most comprehensive thing of its kind that has yet been attempted, and one which focusses within reasonable limits all the most important facts and figures relating to the subject with which it deals. Indeed, several of the large works have arranged for the distribution of copies to the heads and foremen of their various departments; and if such officials as these are thereby made acquainted with the conditions they have to face, the volume should render an invaluable and lasting service to British industry. Incidentally it may be remarked that the reception accorded the Commission was most generous. Mr. C. M. Schwab threw open all the works of the United States Steel Corporation, and others were equally courteous.

Mr. Jeans, whose report is by far the largest, attributes the recent remarkable progress of American trade to the low price of raw materials, the low cost of labour measured in terms of efficiency, and the cheapness of railway transport. Mr. Sahlin is in agreement with these conclusions; but, on the other hand, Mr. Enoch James, writing of steel works practice, remarks: "After much consideration the conclusion I have arrived at is that the American workmen do not work so hard as the men in England. . . . They are much more desirous of getting out large quantities." More and closer supervision was noted. Mr. Jeans informs us that private firms are not afraid of the Steel Corporation or Trust. "In every part of the United States," we read, "plants are entering the lists to compete against the Steel Corporation. It has been observed," continues Mr. Jeans, "that the best returns on capital during the 'lean years' were not generally those of the larger enterprises, but those of a few smaller firms." On the subject of trade unions, we learn that "few employers are ready to acknowledge that they have any influence worth naming." Space will not permit us to place this excellent work under further contribution, and we can do little more than give a clue to its varied contents. We recommend it, however, to the serious consideration and attention of our readers.

"SUBMARINE WARFARE, PAST, PRESENT, AND FUTURE."

Grant Richards. 7s. 6d. net.

MR. HERBERT C. FYFE, the author of the article on "Submarine Boats" which appeared in our last issue, has given us in this volume the result of several years' careful study, and has at the same time succeeded in presenting the subject in an interesting and popular form. An introduction has been written by Admiral the Hon. Sir E. R. Fremantle, G.C.B., C.M.G.; and Sir Edward J. Reed, K.C.B, F.R.S., contributes a short article on the probable future of submarine boat building. The latter eminent authority on naval construction thinks that the future development of submarine engineering will be on triple lines :—

> (1) Vessels for the defence of ports and harbours, with sufficient means of proceeding outside to give the defence a certain limited power of attack in the approaches; 2) vessels primarily designed for attack, and therefore capable of proceeding to sea for considerable distances; and (3) smaller vessels to be taken to sea in ships, as part of their equipment, and capable of being lowered to take part in a battle, and raised again, and re-stowed on board when no longer needed in action.

Mr. Fyfe divides his book into three sections: the first deals with the construction of the modern under-water vessel, and its value in naval warfare; the second gives a short history of its development up to the present time; and the third forms a valuable appendix to the whole work. The author's ideal submarine boat has, he remarks, "a speed as great as that of the fastest torpedo-boat, and a very wide radius of action, excellent sea-keeping powers, unlimited quantities of air for power and for respiration by the crew; a means of directing its course by vision upon a moving object whilst itself remaining invisible beneath the surface; and is very habitable and comfortable for long periods."

A chapter is devoted to the discussion of a possible "antidote to submarines." Various defensive projects are described, but Mr. Fyfe is inclined to deprecate their claims to efficiency. "The means of attack against submarines at present are (1) by quick-firing guns; (2) by firing shells full of high explosive, which, bursting in the water near the boat, will beat it in; (3) by firing explosives at the end of a spar." Assuming that a submarine is obliged to rise to the surface to take bearings before attacking a ship, the third method appears to be the one most favoured by the Admiralty, and its value was tested last year by experiments carried out at Portsmouth by H.M.S. *Vernon* and the destroyer *Starfish*. On the starboard side of the latter vessel "certain plates had been strengthened, and above there was a crutch upon which worked a spar or outrigger torpedo . . . a stout pole 42 ft. in length, at the end of which was an explosive charge of 32 lbs. of wet guncotton, explodable by an electric current by the crew in the boat. Normally, this boom stows inboard and forward, but on going into action it is slung out well forward, and immersed in the water at the proper moment. This immersion carries the boom end downward and aft, and it is exploded directly the submarine is passed. The idea is that the speed of the destroyer will carry her past the centre of the explosion before the full effects reach her."

In the appendices, detailed descriptions are given of the new British, French, and American submarines, and the general interest of the volume is enhanced by fifty unique illustrations from drawings and photographs.

"IRELAND, INDUSTRIAL AND AGRICULTURAL."

Edited by William P. Coyne, Superintendent of the Statistics and Intelligence Branch of the Department of Agriculture and Technical Instruction for Ireland. Browne and Nolan, Ltd., Dublin, pp. 532. 5s. net.

IN the forty-nine articles which are comprised in this handsomely produced volume, a clear and lucid survey is given of the various economic resources of Ireland at the dawn of the twentieth century. The subjects have been entrusted to writers who have made their particular sections a very special study, and are eminently qualified for the task. Many of the articles deal with vital matters upon which, up to the present, full and accurate information has not been generally accessible, and with regard to which public opinion has not been sufficiently enlightened. The Editor, while carefully avoiding controversial subjects, has endeavoured to provide a handbook which will give the student an accurate view of the growth, or decrease, and present position of Irish industries and general economy ; and this he has succeeded in presenting in an attractive and interesting form. Whilst there are of necessity long and intricate tables of statistics and dry industrial facts, yet in many of the articles these are enveloped in bright descriptive matter, and the work has over 120 half-tone illustrations, together with maps and diagrams, which show at a glance the distribution of the population, geological formation, agricultural activity, railways, canals, etc. The Editor is himself responsible for the sections devoted to railways, canal and river navigation, science teaching and technical instruction, and shipbuilding. It is cheering to observe in the midst of much industrial decadence a healthy development of railway traffic, even in the face of a decreasing population. In 1871 the total receipts from all sources of traffic amounted to £2,272,386, whilst in 1900 they reached £3,806,347, an increase of 67·5 per cent. The largest increase has been in the carriage of minerals—233 per cent.—while the passenger traffic receipts have advanced by 62·4 per cent.

> In one respect (writes Mr. Coyne), in the matter of gauge, the railways of Ireland enjoy an immense advantage over those of Great Britain. . . . Before any of the great lines were laid sufficient experience had been already gained to show that the standard narrow gauge of 4 ft. 8½ in. which had been adopted in England was too small. . . . Since 1849 the Irish railways have used for main line work the uniform gauge of 5 ft. 3 in. . . . Owing to this difference in gauge, there is always the possibility, remote though it may appear at present, that at some future time Ireland may be far in advance of the rest of the kingdom in railway development.

Comparing Irish railways with British, Mr. Coyne says :—

> The cost of the construction of Irish railways, as indicated by the amount of paid-up capital, has been remarkably low when compared with the cost of those of either England or Scotland ; in fact, the average cost per mile is less than one-fourth of the cost in Great Britain. It will be seen that, though the net receipts are much lower in Ireland than Great Britain, yet, owing to the much smaller cost of construction, the average dividend for Irish railways is higher than that in England or Scotland.

In the chapter dealing with canals, the writer emphasises the importance of maintaining their efficient and unrestricted utility as independent competitive routes, and points out the evil of allowing railway companies to acquire the control of short sections of these trunk waterways, and thus effectively to interfere with competition along their entire lengths. The present condition of Irish canals is reviewed, and a sketch given of the course and development of the leading routes. Most of them were constructed early in the last century, at great cost ; but they have, with few exceptions, fallen into disuse and consequent inefficiency.

The short chapter which describes the shipbuilding industry of Belfast and Londonderry speaks of vigorous growth. In the latter town the premier position is, of course, held by Messrs. Harland and Wolff, the builders of the new White Star passenger and mail steamers *Oceanic* and *Celtic*.

> Such has been the energy and enterprise of this company, that from 100 hands in 1858, the number of persons employed has increased to 9,000, and the amount of tonnage turned out by the firm during the past seven or eight years exceeds the production of any other yard in the world. In this connection the following figures are interesting. Messrs. Harland and Wolff turned out tonnage to the amount of 81,316 tons in 1896, 84,240 in 1897, 67,905 in 1898, 82,634 in 1899, 73,897 in 1900, and last year they launched seven ships having a gross tonnage of 92,316.
>
> The greatest successes of this firm are associated with the White Star Line. Indeed, the whole fleet (forty-four ships) of the White Star Company was built by Messrs. Harland and Wolff. It was for the White Star Company that the long type of ocean steamship, with saloon and first-class passenger accommodation amidships, was introduced in 1870. This, though a great advance in ship construction, is only one of the improvements due to the Belfast firm. Every demand, indeed, made by modern commercial necessities, and modern luxurious ideas, has been met by Messrs. Harland and Wolff. The world wanted big ships ; Queen's Island built the *Oceanic* and the *Celtic*. Steady "railway timers" were required, and the *Majestic* and the *Teutonic* were produced. In fine, Messrs. Harland and Wolff have shown themselves pioneer builders of vessels of great size and extraordinary speed.

At Londonderry shipbuilding dates back to early in the nineteenth century, but it was not until 1886 that a proper shipbuilding yard was opened. This, however, was closed in 1892; but in 1898 the Derry industry again showed signs of activity, when the yard was re-opened by the newly-formed Londonderry Shipbuilding and Engineering Co., Ltd., who have since built ships over 380 ft. long for several of the great steamship companies.

> One of the serious drawbacks of shipbuilding in Londonderry is that only the hulls are constructed, and either the hulls have to be towed over, mostly to the Glasgow or Tyne works, for their engines, or the engines have to be brought to Londonderry. This causes considerable loss of time and money. Over 400 men and boys are employed, and as the industry is prosperous and progressive, the number of workers is increasing.

Though Belfast and Londonderry are the chief seats of the industry, shipbuilding is also carried on at Haulbowline, and a decided effort is being made to revive it at Dublin, where a company has been formed to carry on the work on the banks of the Liffey. A dockyard suitable for the construction of vessels up to 300 ft. long is being rapidly put into working order.

Science teaching and technical instruction are arousing a renewed interest in Ireland. As Superintendent of the Statistics and Intelligence Branch of the Department of Agriculture and Technical Instruction for Ireland, Mr. Coyne is able to give his readers a comprehensive survey of the condition of technical instruction in Ireland.

> Whilst eighteen years ago the Irish students formed 11·2 per cent. of the total number of students (including England and Wales), and their grants amounted to 14·5 per cent. of the total grants, the proportions now are only 2·3 per cent. and 1·2 per cent. respectively.

It is hoped, however, that, with the aid of a Government grant of £55,000 per annum, a great improvement on the above returns may be effected.

We strongly commend this book to the careful attention of every British manufacturer who wishes for reliable information concerning the industries and resources of the Sister Isle.

"THE AMERICAN INVADERS."

By F. A. McKenzie. Grant Richards.
2s. 6d. net.

"THE future still waits for us if we will to have it," says Mr. McKenzie in his preface; "but to hold our own there must be reform, far reaching and thorough. It is to help to bring needed changes that this book is written." The author claims to be strictly impartial in his review of British and American trade, but page after page impresses us with the fact that he has a case to make out, and a little racy exaggeration here and there lends a spicy flavour to the whole.

We notice merely with mild surprise that "we are approaching the stage when it seems that the London literary world will sit at the feet of Chicago and New York." As far as we can gather from this informing book, we have little left but the cycle trade, and but for American "cuteness" there can be little doubt but that this would have been in danger, too. It may be remembered that the Americans saw in these Islands an appropriate dumping ground for unsaleable bicycles which were unfit for use on American roads, and that the British public did not rush in and purchase.

The writer calls attention to American preparations to capture the trades of to-morrow. He says :—

> It requires little foresight to realise that very soon the trade in gas engines will increase quite sixfold. To my knowledge at least one American-English house is making careful preparation for this increase, and hopes to scoop the whole business when it comes. There is a German patent gas engine which will also stand a good chance. But one hears no rumours of British firms preparing for this boom.

Verbum sap. But we have known effective preparations made without "rumour."

We have paid dearly enough for our South African possessions. According to Mr. McKenzie, "the coming months may show that we have paid the price to benefit the traders of other lands, and that Americans especially will reap the commercial profits of our triumph in South Africa."

Although there is much matter in this work which is open to controversy, it makes interesting reading, and the author goes fully into the campaign of Mr. Pierpont Morgan and the Standard Oil group, the tobacco war, and the bid for our steel trade and shipping. A chapter of exceptional interest gives an account of the new Westinghouse Works at Trafford Park, contributed by Mr. D. N. Dunlop.

The author emphasises the pernicious effect of hampering legislation on British industries :—

> Americans are succeeding to-day largely because of their climate, their superior education, their longer

working hours, their willingness to receive new ideas, their better plant, and perhaps most of all, because of their freedom from hampering traditions.

It may be noticed that I do not say Americans are succeeding because of the great resources of their country. This, I am aware, is the common explanation. But although the natural resources of America are one of the great ultimate factors in the contest, it is yet possible to attribute too much importance to them at the present stage. England has magnificent resources, and is placed in a spot which naturally makes her a great centre of the world. Here we have iron, and coal, shipping facilities, and mineral wealth of every kind, and it is not for us to complain of the natural resources of our competitors.

What we must complain about is our bad legislation, our neglected education, our indifference, and excessive optimism. Through our bad legislation we have lost and are losing many trades. The tobacco, printing, and electric industries are instances of this. Once Ireland had flourishing tobacco plantations. These were purposely killed in order that the tobacco industry in our then American colonies might be fostered. Our erstwhile colonies are now a rival nation, but the revenue restrictions still make tobacco growing here practically impossible. There is no reason, climate or other, why Ireland to-day should not produce great tobacco crops.

In the concluding chapter the author deals with the question, "Can we meet America?" and discusses the attitude which should be taken up with regard to the so-called "invasion":—

So far from opposing the introduction of American improvements, even to the profit of the Americans in this country, we should welcome them and aid them in every way. . . . We have, it is true, to decide whether we are going to be a subordinate people, allowing the Americans to take the supreme rule of our industries, or whether we are going to retain our old chieftainship. But we will not keep our place by any other method than that of raising our industrial conditions up to those of America. Only by improving the physical growth and mental development of our people, and by putting the best brains of our nation, unrestricted by old traditions, into our industrial concerns can we hope to advance. The time when the governing classes of this country treat commerce as a matter for lofty patronage and scornful misunderstanding must go by. To-day we are hindered in a hundred ways by inadequate and pernicious laws. We see industry after industry almost throttled by mere legislative stupidity. We find our traders refused the facilities which every other progressive government willingly gives its people. We witness commerce fostered in other lands, while in England it is severely left alone.

He concludes as follows:—

The purchase outright of British manufactories by Americans is a blow to our prestige. But in many instances the American purchasers settle in our midst, and become English in their turn. England has in the past shown great power of absorbing outer peoples; in the future she will show the same. To build high barriers against Americans would be folly. If we wish to hold what America is taking from us we must do so by proving ourselves as good men as the Americans; as good in business energy, in education, in technical training, in working capacity, and in inventive skill.

"THE NEW SOUTH AFRICA: ITS VALUE AND DEVELOPMENT."

By W. Bleloch. With illustrations, maps, and diagrams. W. Heinemann.

A NEW and revised edition of Mr. Bleloch's work is well-timed. Now that we have entered into the possession of our recently-acquired territories, it is interesting to pass in review the predictions of those who undertook to speak of their latest resources, in order that we may see how far these anticipations were justified by actual fact. One of the principal objects the author had in view in writing "The New South Africa" was to convey to those who had not lived in the country, but who had undertaken a great war on behalf of its future, some idea of its natural resources.

The estimate of available gold was sufficiently high to challenge unbelief. After a year's further study, however, the author expresses confidence in the correctness of his conclusions:—

In August, 1901, and in January, 1902, the reefs were cut in the Turf Club boreholes; and although the actual assay results are not so good as might have been expected from the records of the outcrop mines, the ore bodies are of payable grade, and their continuity to a depth of nearly 5,000 ft. is conclusively demonstrated. Measuring along the plane of the reef, these results may be taken as proving the ore bodies for over 10,000 ft., of which only a very small portion has been exhausted. Apply this figure of practically two miles of dip to the ten miles of the Central Rand only, and some idea of the importance of the "strike" will be obtained. The assay results of the eastern boring indicate an extraction value of 36s. 3d. per ton for the South Reef and about 28s. 9d. per ton for the Main Reef leader, while in the western the record is not so good. Even in the richest outcrop mines poor zones are encountered (as well as conversely rich zones in poor mines), and, in any event, a core assay is no safe criterion of value of large blocks of ground. Future results will probably confirm the general average of 41s. per ton for this particular section of the Rand.

Other discoveries have lately been made which tend to show that new lines of banket reefs may be opened up, and, on the whole, the evidences are such that it may be confidently expected these new lines of reef, besides making up for any possible shortcomings of the Main Reef series, will probably swell the actual returns far beyond the great estimate given of the gold-producing value of the Rand. Vigorous exploratory work is about to be commenced on both the eastern and western extensions of the Main Reef series. In the far eastern section of the Rand, the Modderfontein Deep Levels Company struck reefs officially correlated with the Van Ryn series at a depth of about 3,070 ft. in February, 1902.

Some confirmation as to the estimates of the Rand output in the next few years is furnished by the statement of Mr. A. R. Goldring, Secretary of the Transvaal Chamber of Mines, before the Water Supply Commission, that within five years there will be 17,000 stamps running on the Rand, turning out gold to the value of between £50,000,000 and £60,000,000 a year.

The appointment of a Commission to inquire into the working of the gold law is likely to result in such reforms as will make prospecting practically "free," and, which is equally important, inexpensive.

The Rand mining industry is making rapid advance to the position it had attained prior to the war. Milling was commenced by three companies in May, 1901, and in the table which follows are shown the monthly crushings and outputs, together with the number of stamps employed :—

Month.	Companies.	Stamps.	Tons Milled.	Ounces, Fine Gold.	Value. £
1901.					
May ...	3	150	15,306	7,479	31,271
June ...	7	350	40,111	19,779	84,014
July ...	7	365	46,436	25,960	110,269
August ...	7	380	47,365	28,474	120,953
September	8	414	53,187	31,936	135,654
October ...	8	440	54,908	33,393	141,848
November	10	554	67,882	39,075	165,986
December	12	653	86,811	52,897	224,702
1902.					
January...	21	1,075	143,756	70,341	298,786
February	22	1,260	158,151	81,405	345,782
March ...	29	1,540	211,727	104,127	442,303
April ...	31	—	—	119,588	508,000

In an informing chapter on Industry and Commerce in South Africa, the writer shows that these are handicapped by the cost of skilled labour, but speaks hopefully of the opportunities that will be afforded for establishing iron and steel works :—

The great engineering works on the Rand have been called into existence by the requirements of the mines, and might more properly be considered as part of the mining industry. They are extensive and well equipped; some of the workshops can turn out heavy machinery well made and well fitted, and all can execute repairs, make castings, and fit in parts with efficiency and despatch. But so far the great cost of skilled labour, and other items of expenditure, have made it impossible to compete with home and American industry in machinery manufacture. When the superior iron ores of the country are worked, a change in this respect will take place, and in the course of the next decade it is fairly certain that iron foundries on a large scale will be working. Branches of the firms at present supplying the Rand with mining machinery, or others, will be established at Johannesburg or Middelburg; the first to come will no doubt secure the lion's share of the trade.

It is more than likely that a start would have been made in this direction already, had it not been for the fact that the principal mining groups have large financial interests in one or more of the great firms making machinery for the Rand, and while the mines continue to be controlled wholly by the present people, they will naturally support their own factories; but if new mines are opened and new capital is induced through liberal measures of Government, there will undoubtedly be excellent opportunities for establishing many different branches of iron and steel manufacture, including machinery.

In passing, it may be observed that, independently of the larger and more important uses of iron and steel in connection with the mining industry of the Transvaal, there are many requirements of the country which could be supplied immediately from Transvaal iron ores, and which offer large profits to anyone taking up their manufacture. For instance, there will be a demand for iron fencing standards, Kaffir pots, etc., etc.

The Rand Central Ore Reduction has for some time past been producing pig-iron from Middelburg ores.

The author estimates that the amount of good coal available in the Transvaal is 60,000,000,000 tons :—

The districts where the coalfields are best developed geologically, and where the best qualities of coal are found, are Middelburg and Ermelo. In these districts the percentage of good coal to the whole bulk is higher than in the other districts. A considerable quantity has already been sent to Delagoa Bay for navigation purposes, and, owing to its high heat-raising power and its low percentage of ash and sulphur, it has found a good market among the shippers. Coal for a market of this kind must of course be picked and dressed. Hitherto, too little attention has been paid to this work, and only a few of the collieries have the necessary machinery; but as the export coal trade develops this state of affairs will be altered, and navigation coal from the Transvaal may be expected to take a high place among South African coals in the market. The rapid development of the Natal coal industry during the last few months indicates what can be done. One chief necessity for stimulating this trade is the authorisation of railways required to tap the coalfields. A railway connecting Springs with the Delagoa line beyond Middelburg would traverse the richest coalfields in the country, and the other line which was authorised before the war, that from Ermelo to Machadodorp, would open up another first-class district. Taking Middelburg as the centre, the distance to Delagoa Bay is only 250 miles. At a railway rate of ½d. per ton per mile, which should be a remunerative rate for down traffic to the coast, the freight to Delagoa Bay would only be about 10s. 6d. per ton. A halfpenny per ton per mile is the rate charged by the Cape Colonial railways for intercolonial traffic. In fact, for traffic coastwise the rate might even be reduced to ¼d. Assuming that the coal could be mined and sold at the pithead at 10s. per ton, after paying working costs and all charges, and leave a profit at that figure, the coal could be sold at Delagoa Bay at about 21s. per ton; at a rate of ½d. per ton per mile it could be sold at 15s. per ton. The ruling price at present for Natal coal at Durban is 30s., and the supply, on account of lack of railway facilities, cannot keep up with the demand. Some of the Natal coal companies are paying 10 per cent. every three months in dividends, and carrying equal amounts to reserve. The profit on Natal coal at the price of 30s. is 15s. per ton. To open the Transvaal coalfields for a profitable export trade, one of the principal necessities is an intelligent adjustment of railway tariffs. Needless to say this could not be obtained from the Netherlands Company. The great enhancement in value of coal in Europe affords the opportunity, and the new Government should leave nothing undone to develop the Transvaal coal industry. Besides the local demand in the country itself, it should become a strong competitor for the shipping trade of the Southern Hemisphere. Japan and Australia have secured the coal trade of the Far East, and South Africa is certain to have similar success in the South. The Transvaal must be energetic or Natal will get the monopoly.

The author mentions that there is an excellent opportunity for profitable coke manufacture.

Some experts have stated about Transvaal coal that it will not make good coke, that the product is too soft and too impure to be used for metallurgical purposes. But the reason for this statement, which may be accepted as true in the past, is that proper methods have never been applied to coke production in the Transvaal. In fact, the preparation of coal and its products for the market forms a branch of industry which is in its most primitive stage.

In the North of England good coke is made from vastly inferior coal to the bright coal of Middelburg. The best and latest machinery is required in the manufacture of coke as in the manufacture of anything else, and a rich reward awaits anyone who enters the field adequately equipped for the production of coke. One enterprising little company, the "Home Coal Estates," has done something in this direction with marked success. Its products are in great demand on the Rand, greater, in fact, than it can satisfy, and the trade is only in connection with the limited requirements of the mines in the smelting of gold. With proper machinery which would remove most of the impurities and especially the greater part of the iron pyrites from the coal, a tough, high-class, pure coke could be made from Middelburg bright coal, and such a coke would speedily create a market for itself. The smelting of iron, lead, and copper would be made possible, with the consequence that numerous mines possessing rich ores of these minerals would quickly be opened up. Iron foundries and steel-works would begin to appear, and a Transvaal Black Country would come into existence. This applies especially to Middelburg, Pretoria, and Lydenburg districts.

In addition to a great deal of valuable information on the gold industry, and the other mineral wealth of our new colonies, the author has much to say about the dynamite monopoly, agriculture, immigration, and the present inhabitants. The work is well produced, and from a pictorial standpoint alone will well repay inspection.

Die Schiffbauindustrie in Deutschland und im Auslande. By Tjard Schwarz and Dr. Ernst von Halle. In two volumes, with numerous tables and diagrams. Berlin: Ernst Siegfried Mittler und Sohn, 68-71, Kochstrasse. The first volume of this interesting compilation treats in an exhaustive manner on the shipbuilding of the world, and compares the strength of the shipping of the various great Powers. The second deals exclusively with the German shipping industry (naval and mercantile), and contains some instructive and detailed plans of the more important shipbuilding yards. Altogether a most useful work of reference, reflecting the greatest credit upon all concerned.

NEW CATALOGUES AND TRADE PUBLICATIONS.

These catalogues may be had free of charge on application to the firms issuing them. Please mention PAGE'S MAGAZINE when you write. Manufacturers of Engineering and Electrical Specialities, etc., etc., are invited to forward for review in this column copies of their catalogues, price lists, and circulars, as soon as issued.

The Allis-Chalmers Company, Chicago, Ill., U.S.A.—We have received from this firm a number of booklets, each dealing separately with their various specialities in mining machinery. There is abundant evidence that more than ordinary care and forethought have been exercised in the compilation of these catalogues. The master hand of the designer is apparent, and much credit is also due both to the engravers and printers for the excellent effects obtained. The very large field which is covered by this firm in the manufacture of all kinds of mining machinery is so well known that it is hardly necessary here to give even a passing notice to their many specialities. Perhaps the most interesting of the catalogues before us is a booklet of 208 pages and cover (sixth edition of Catalogue No. 3) dealing at length with their roasting, smelting, and refining machinery for the purpose of extracting gold, silver, lead, and copper from ores by igneous processes. It includes various kinds of ore samplers, grinders, and breakers, also oxidising, chloridising, roasting, smelting, and blast furaces. Altogether a very useful set of catalogues, and well worth the attention of managers and others concerned in the development of mining properties, small and great.

James Neville and Co., Springfield, Ohio, U.S.A.—Pamphlet K, of 46 pages and cover, illustrates and describes the latest types of the Samson turbine, built by this firm, and for which they claim "the finest results known to the art of turbine building." We are told that over 15,000 (or 1,000,000 h.p.) Leffel wheels are now in use, which certainly speaks well for the excellence and satisfactory working of this turbine. The plates illustrating installations at Niagara Falls, Rock Island, etc., are especially interesting.

Cole, Marchent and Morley, Ltd., Bradford.—This firm has just issued a well-printed and illustrated booklet of 124 pages and cover, entitled "Condensing Equipments." In addition to the particulars usually embodied in a catalogue, there is much matter of a descriptive and pithy nature, rendering it one of the most complete catalogues hitherto published in connection with condensing and cooling. The workings of condensing plants, heaters, evaporators, cooling plants for steam power installations, pumps of various types, feed-heaters, oil-separators, water-softeners, etc., etc., are here all so lucidly explained and exemplified by illustration, that we feel sure the book will be read with avidity by those interested in this class of machinery.

The Glacier Anti-Friction Metal Company, Ltd., London.—A pamphlet of 24 pages and cover, containing a few tests and reports on Glacier Anti-Friction Metal, in which we are informed that this material has been tested and endorsed not only by engineers, railway and steamship companies, but by many Governments of the world, and there are also reprints of a few commendatory letters from customers. We are officially informed that the jury at the Exposition de Lille have awarded this firm the silver medal for their Glacier Anti-Friction Metal, this being the highest award given for anti-friction metal.

W. T. Ellison and Co., Ltd., Irlams-o'-th'-Height, Manchester.—An eight-page pamphlet describing and illustrating their principal speciality, viz., turnstiles, of which several kinds are mentioned. The exit cage turnstile calls for special notice. This is an ingenious contrivance by means of which it is possible to obtain ingress or egress only, according to its adjustment, the object being to prevent congestion at the entrances and exits to and from race-courses, pleasure grounds, football and cricket clubs, etc. As a kind of auxiliary to this catalogue there is a four-page pamphlet illustrating another of the firm's specialities—pumping machinery, the principal of which is the "Niagara Falls" double acting, pulsating steam pump, the price list of which is also given.

Thomas A. Renshaw and Co., 8, Bath Street, City Road, London, E.C.—As London agents for the Universal Automatic Feed Handmill, Messrs. Renshaw & Co. have issued a descriptive pamphlet and price list of this and other machine tools, including the Taylor automatic tool grinder, universal cutter and grinder, Clark's improved boiler head flanging machine, engine lathes, built by the Goddard Machine Co., Wheeler's planers, etc., etc. Of interest to all users of machine tools.

Fuller and Co., 9, Red Lion Court, Cannon Street, E.C.—A large quarto 70-page illustrated catalogue and price list of their many specialities in electrical appliances, including the Alpha cables and wires, electric light casings, "Lux" incandescents, porcelain switches, fuse boards, resistance frames, switch boards, arc lamps, ammeters, voltmeters, and much more useful paraphernalia attendant on the application of electricity in various ways.

Mosses and Mitchell, 69-71, Chiswell Street, London, E.C.—Catalogue and price list of the "Original" vulcanised fibre. This fibre, we understand, has been upon the market for over twenty-eight years. It is used largely for railway, electrical, and general mechanical purposes, and possesses peculiar qualities which render it entirely different from any other known material. In an interesting description of its manufacture we are told that a certain prepared vegetable fibre is treated with "powerful chemical agents," then submitted to very heavy pressure and brought to practically a homogeneous condition, after which the chemicals are extracted, and by means of "an extremely delicate chemical process" it is converted into the substance known as "vulcanised fibre." The purposes to which the material can be applied seem to be almost unlimited, and one of its peculiar qualities is that of electrical insulation.

Atlas Tool Works, Levenshulme, Manchester.—The latest catalogue to hand from this firm is a booklet containing some fifteen leaflets with reproductions of their principal specialities—lathes, radial, horizontal drilling and boring machines, slotting, planing, and milling machines, and vertical turning and boring mills. The catalogue as a whole is excellently designed and printed, but we venture to suggest that better effects could be obtained from the blocks of photos 64 and 65 by the exercise of a little more care on the part of the printers. This, however, is only a detail.

The Empire Engineering Co., Failsworthe, near Manchester.—A pamphlet of 20 pages and cover illustrating, by means of excellent half-tone engravings, their various specialities in Lubricators (the "Sight Feed," "Empire," "Piston," "Compact," "Simplex," "Boss," "Rex," and "Drip"), Safety Valves ("Dwarf," "Pop," "Empire," "Empire Spring," etc.), Steam Driers ("Stemtriff," etc.), the "Empire" Steam Trap, and Asbestos-Packed Water Gauges. The last named are made of best gun-metal and are tested to 300 lbs. per square inch.

The "Harris" Patent Feed-Water Filters, Ltd., 2, Hamilton Street, Greenock.—A 16-page pamphlet containing a short treatise on Feed-Water Filters and their use as applied to boilers, also various sectional drawings and half-tone blocks, and a list of some 250 vessels—including men-o'-war of many countries, liners, merchantmen, steam yachts, etc., etc.—to which the Harris Feed-Water Filters have been fitted. Two large blocks representing H.M.S. *Terrible*, and the *Campania* and *Lucania* are especially interesting.

The C. W. Hunt Co., of New York and Staten Island.—Catalogue No. 029, containing 20 pages and cover, profusely illustrated by half-tone blocks of the first quality, the excellent effect of which is heightened by the superior art paper on which the catalogue is printed. The booklet is entitled "Hunt Cable Railways for handling Coal and Merchandise," and deals at length with the three varieties of Cable Railways manufactured by the firm. The first is called the "Heavy Cable Railway," which is operated as follows: The steel cable is kept constantly in motion and the cars are attached at will at any point, and are drawn around the tracks by the cable until the grip is released. Secondly, there is the "Double Shuttle Cable Railway" in which two cars are used—one going out loaded and the other returning empty, passing each other on a switch, or on a double track. Thirdly, there is the "Single Shuttle Cable Railway," in which one car only is used—being drawn by power outward to the dumping point, automatically dumped, and then drawn back to the loading point. The manufacture of all the necessary appurtenances for these railways is undertaken by this firm—including driving engines, cars of all kinds, rails, tracks, etc.—and we are told that "no Waltham watch or Baldwin locomotive is more carefully designed, the detail more thoroughly studied, or the materials more carefully selected and worked into shape than are the working parts of the Shovel, Elevator and Automatic Railway."

J. H. Williams and Co., Brooklyn, New York.—An excellent little brochure of 76 pages and cover, containing some more than ordinarily fine illustrations from interior and exterior views of their works and manufactures in iron, steel, copper, bronze, and aluminium drop forgings, including air valves, wrenches of various types, automobile parts, starting levers, thumb nuts, screws, wire rope sockets, ammonia union forgings, dies, crank shafts, handles, collars, and many others. This firm are the sole makers of the Vulcan brands of drop-forged specialities; and annealing, tempering, and case hardening are done to order. Pages 62 to 65 of the catalogue are devoted to a telegraphic code of words (supplemental to the ordinary standard codes used) for their principal specialities.

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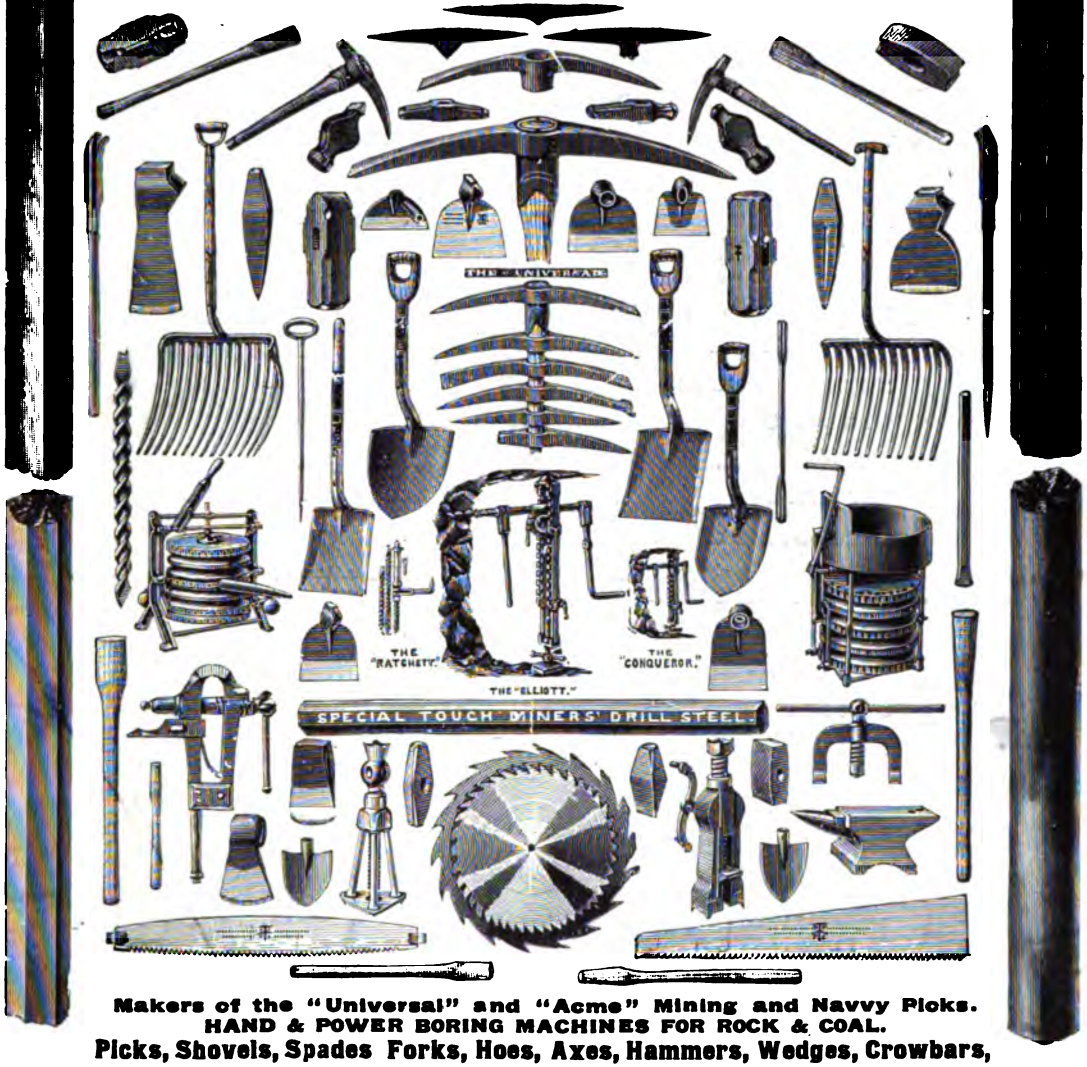

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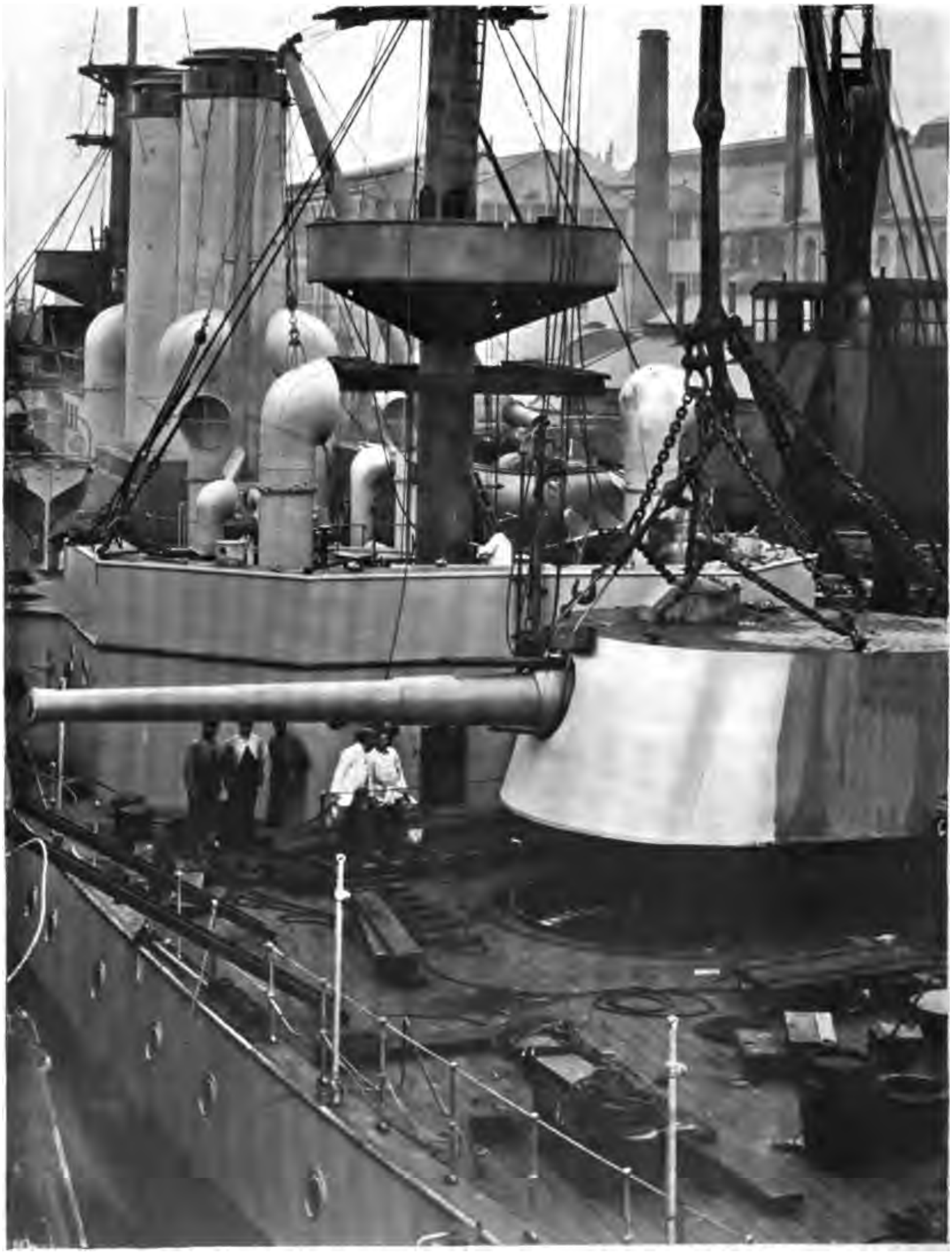
CONTENTS

No. 4. **OCTOBER, 1902.** **Vol. I.**

GUN AND GUN-HOUSE BEING LIFTED ON BOARD "EIDSVOLD"		Frontispiece
THE GUN v. THE ARMOUR PLATE With Eight Illustrations.	John Leyland	371
THE DEVELOPMENT OF "WIRELESS" TELEGRAPHY—II. Marconi's System. With Seven Illustrations.	H. C. Marillier	383
THE WORLD'S GREATEST SUSPENSION BRIDGE With Six Illustrations.	W. B. Northrop	391
MILLING MACHINES-IV. Illustrates boxes of gears for producing positive feeds. It also treats of Circular Milling and Vertical Spindles.	Joseph Horner	398
NAVAL NOTES Illustrated Monthly Notes on Naval Construction and Armament.		409
NOTES AND NEWS		419
WATER-TUBE v. CYLINDRICAL BOILERS With Seven Illustrations.		423
ESTIMATES	Claude W. Hill, A.M.I.C.E., M.I.E.E.	436
LOCOMOTIVE ENGINEERING NOTES		439
MODERN PRACTICE IN MILLING AND AMALGAMATING—II.	Edgar Smart, A.M.I.C.E.	442
WORKSHOP PRACTICE A Résumé of Machine Tools, Cranes, and Foundry Matters for the Month.		450
OUR MONTHLY RÉSUMÉ	The Editor	454
NOTABLE BRITISH PAPERS OF THE MONTH With Seven Illustrations.		463
REVIEW OF LEADING CONTINENTAL PAPERS		478
BOOKS OF THE MONTH		485
NEW CATALOGUES AND TRADE PUBLICATIONS		487



HOISTING IN AN 8-IN. QUICK-FIRER.

The Norwegian Ironclad *Eidsvold* at Messrs Armstrong, Whitworth and Co.'s yard, Elswick.
Vide "The Gun *v.* the Armour Plate."

PAGE'S MAGAZINE

An Illustrated Technical Monthly, dealing with the Engineering, Electrical, Shipbuilding, Iron and Steel, Mining and Allied Industries.

VOL. I. LONDON, OCTOBER, 1902. No. 4.

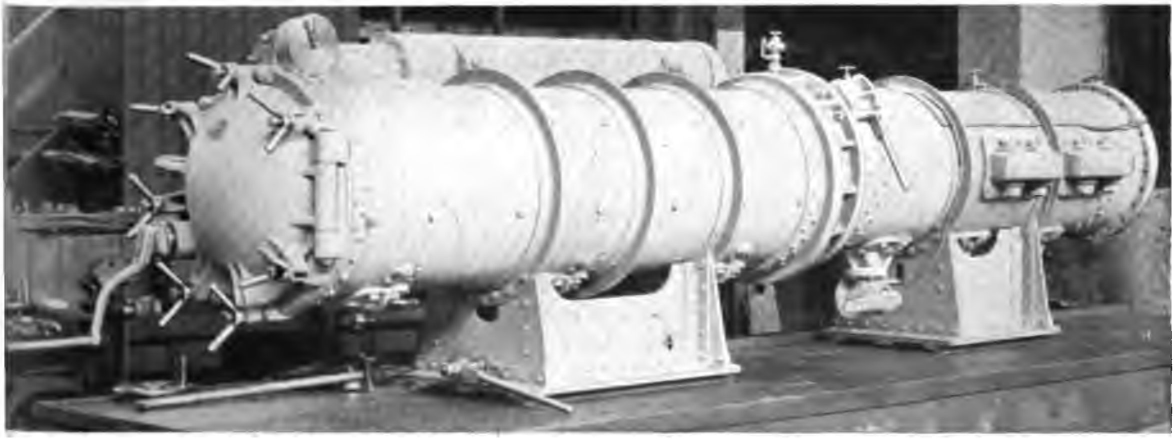
THE GUN *v.* THE ARMOUR PLATE.

BY

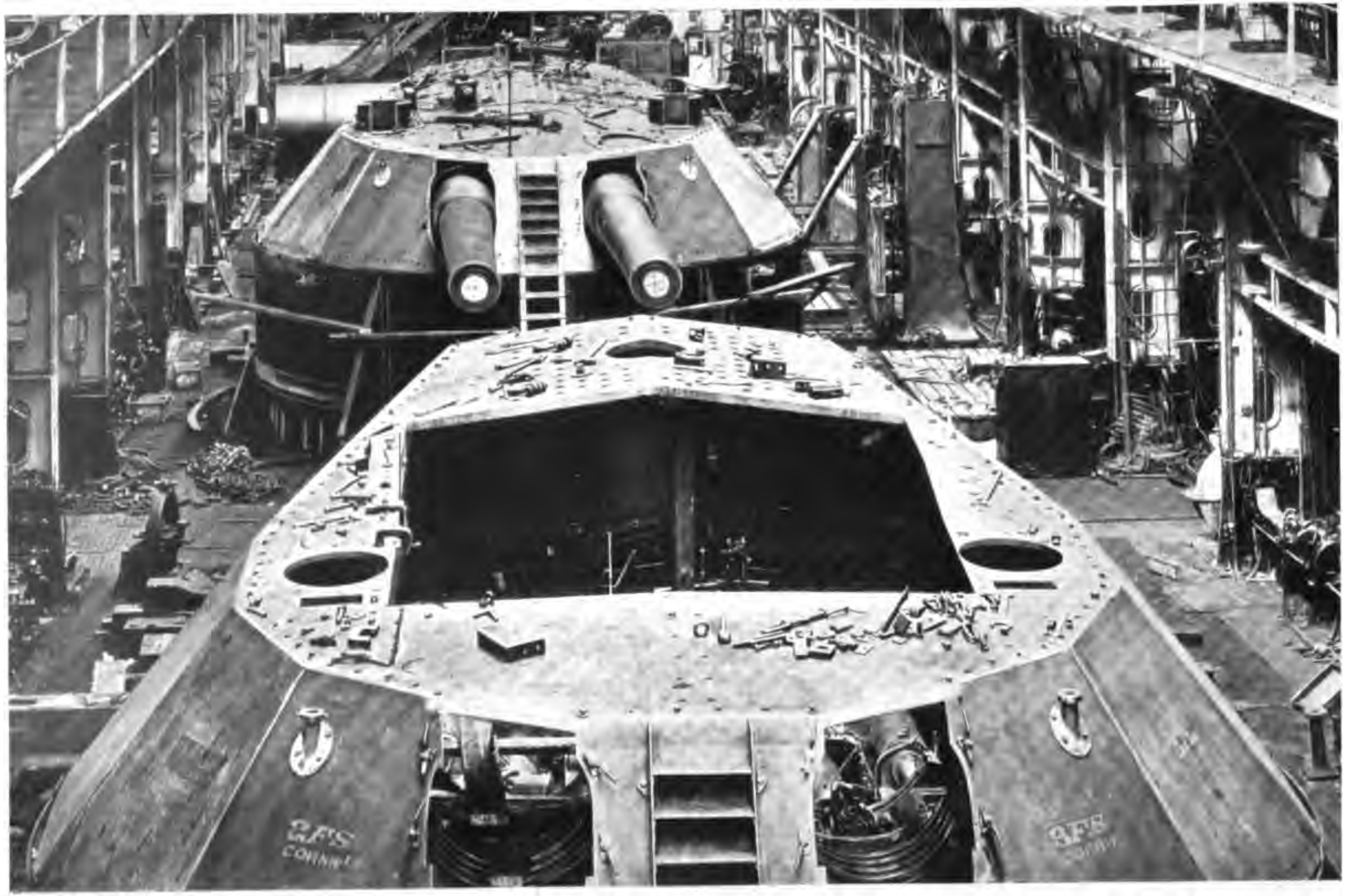
JOHN LEYLAND.

The introduction of the "Johnson cap" and the recent experiments with the *Belleisle* make the question of the relation between the gun and the armour plate one of very practical consequence. The Author, in the following article, has given a contribution of undoubted interest, and shows very clearly what is the present position.

THE vital question of protection from attack is one of extraordinary interest; and, looked at from a naval or military point of view, it might take us back to very distant times in the history of humanity. It is, in effect, the necessary consequence of that eternal antagonism between the attack and the defence which is as old as humanity itself. It has also great modern importance in its special relation to the armouring of ships of war, because upon the defence that it is possible to give to them must depend their design and construction. The announcement made in May that the Lords of the Admiralty had witnessed at Messrs. Vickers' range at Eskmeals, near Barrow, trials against armour which reversed previous experience and were a total surprise, and the experiments with the *Belleisle*, make the question of the relation between the gun and the plate one of very great gravity and practical consequence. The purpose here is to show how the position stands. We were told that the



SUBMERGED TORPEDO TUBE.



TWIN MOUNTING FOR 12-IN. GUNS.

A recent view in the works of Messrs. Armstrong, Whitworth and Co., Ltd.

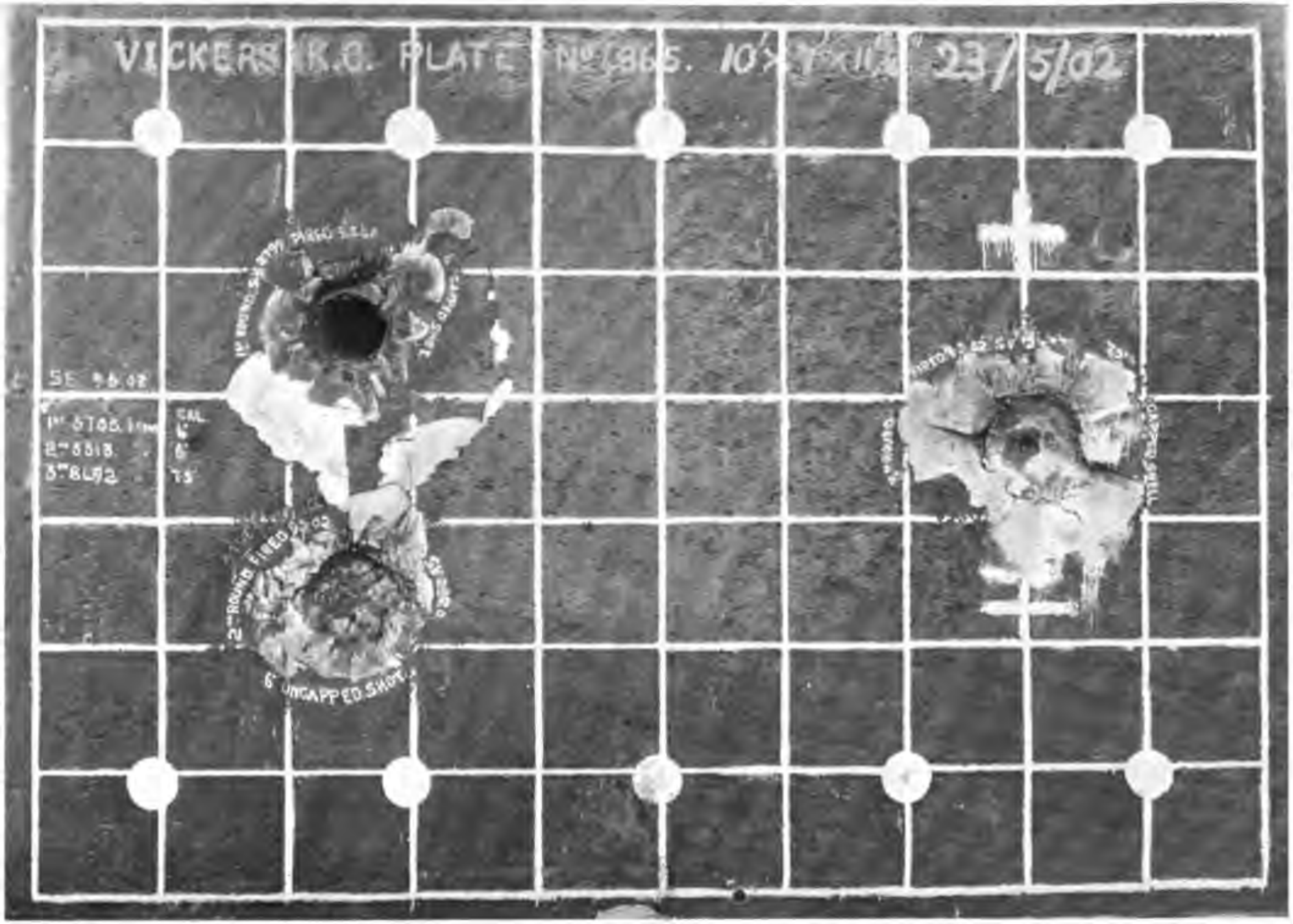
"Johnson cap" had enabled a 105-lb. armour-piercing shot of 6-in. calibre to completely perforate a 6-in. Krupp-cemented armour plate, being fired with a striking velocity of 1,971 foot-seconds (fig. 5, round 3); that the same cap had sent a 6-in. 105-lb. projectile, fired with a striking velocity of 2,799 foot-seconds, through a 12-in. plate of the same character (fig. 1, round 1); and, finally, that the same cap had carried a like shot completely through the same 12-in. plate with a striking velocity of 2,786 foot-seconds (fig. 2, round 4).

These astonishing results, and particularly the fact that a capped 6-in. projectile had twice completely perforated a 12-in. plate of the best Krupp armour, whereas an uncapped shot, with a similar striking velocity, had only penetrated 3 in., caused a veritable sensation. It was said that the Admiralty must have been very neglectful to overlook the merits of so important a device as the "Johnson cap," which could be fitted on board ship, and would give a gain in armour-piercing power of 30 per cent. Undoubtedly the cap had shown its usefulness for direct fire, and might be depended upon to give results analogous to those attained at Barrow in the case of projectiles striking within about 20 deg. of the normal. Beyond that angle the cap is, perhaps, of less value, but it must be remembered that a very large proportion of shots may be expected to strike at a near approach to a right angle with the face of the armour. It might be unfair, however, to censure the Admiralty for neglect in this matter. Whatever has been the case in the past, there can be little doubt that the present Board, which has now, with few changes, ruled affairs for several years, is very alert, and that it regards all new inventions and discoveries with an open mind. It was too readily assumed that the trials at Barrow were a revelation. As a matter of fact, those who were acquainted with the history of the struggle between the gun and the plate were not surprised to find such results recorded. For the capped armour-piercing shot—the *projectile coiffé*—was no new thing, and trials had been made with it during the previous eight years which must have placed in the hands of the Admiralty Board a good deal of information upon the subject. Until more is known it would not, therefore, be right to blame the Admiralty for having neglected a great opportunity.

The use of the cap is, in fact, only one part of the great problem arising out of the contest between the gun and the armour. Much damage may be done, and great demoralisation be caused on board a ship in action, by showers of weak common shell, but, in all modern ships, the protection of men is now carried to a high degree, and the final resort must be to the use of the armour-piercing projectile. The first *Belleisle* trials threw a great deal of light upon the disposition of men in our existing ships, and there can be little doubt that the practical experience gained would enable many lives to be saved in any future fleet action. But, after all, if a ship is to be effectually dealt with, it must be by means of penetrating the armour, and it seemed to be a teaching of the first *Belleisle* trials that the secondary armaments of the battleships of the *Majestic* and *Canopus* classes are for this purpose comparatively ineffective. Wherever ships are built exhaustive trials are now being conducted, all tending to improvement both in guns and armour.

Steel armour plates originally and for a long time proved very brittle, and gave small promise of success; but a quarter of a century ago steel in one form or another began to be adopted. In England great efforts were made to secure toughness, and the Sheffield firms of Cammell and Brown introduced what were termed compound or hard-faced plates, consisting of a hard steel face upon a soft wrought-iron back or foundation. Krupp began to make such plates at Essen on Wilson's system in 1891. Compound armour held the field from 1880 to about 1892, but the advantage over the improved steel was not conspicuous. A further improvement was due to the use of nickel as an ingredient in the steel, introduced by Schneider in 1890, and adopted for the British Navy in 1896. When compound armour was introduced, armour-piercing shot of cast-iron, chilled by the Palliser or some other similar process, were employed, and the plates were so successful that the heads of the Palliser projectiles were crushed, unless extraordinary striking energy was developed as compared with the resistance of the plate.

Thus the superiority rested temporarily with the plate; but, about the year 1896, when chrome-steel projectiles came in, hardened at the head by water or oil, the case was changed. The extreme



FIRST ROUND
SECOND ROUND

THIRD ROUND

RESULTS OBTAINED AFTER FIRST, SECOND, AND THIRD ROUNDS AT MESSRS. VICKERS, SONS AND MAXIM'S RANGE AT ESKMEALS, AGAINST A 12-IN. VICKERS K.C. PLATE, ILLUSTRATING THE ADVANTAGE OF THE "JOHNSON CAP." (FIG. 1.)

(For details see opposite page.)

hardness, combined with toughness, which characterised the new shot, was so great that the piercing power was increased fully 20 per cent., and it generally happened that perforation was effected without any damage to the shot. Extraordinary efforts were consequently made in every direction to defeat the new projectile, and once more a swing of the pendulum occurred. Cemented plates were brought in, possessing the two qualities of hardness and toughness. Captain Tresidder discovered that by the application of a water jet to the hot metal a degree of hardness was produced which, in ordinary plunging, was prevented by the formation of steam, and Harvey, in America, perfected a process of carbonisation by contact with carbon at high temperature for several days, the face being finally water-hardened. A 10½-in. Harvey plate at Indian Head was successful against an 8-in. Carpenter steel shot of 250 lbs., with a velocity of 1,700 foot-seconds, and a perforating power of 14·8 in. of wrought iron. This plate, therefore, was much superior to the steel and compound plates then being supplied to the *Royal Sovereign* and other ships, and, at the same time, Schneider was making plates which approached the Harvey system in quality. The advantage gained was enormous, and on steel faces, hardened by the Harvey and Schneider processes, excellent projectiles broke up, and sometimes became disintegrated.

The Harvey process has been employed in the armour of a great many ships of war, but not long after it had been introduced Krupp came forward with the process which has now superseded it, and which, if we except the action of capped projectiles, has withstood the attack of armour-piercers. Krupp's plates, with which he began to experiment in 1893, are described by him as "one-side-hardened nickel steel plates" (*Einseitig gehärtete Nickelstahlplatten*), and are known in this country and in America as "Kruppised" or Krupp plates. Their extreme hardness is carried by a special process to a certain depth, while the back of the plate is very tough and enduring. When, in 1896, a trial of the new Krupp method was arranged, preliminary to the sale of the rights to the English firms of Brown, Cammell, and Vickers, and the French companies of Schneider, Châtillon, and Saint-Chamond, plates of various thicknesses were tested. The projectiles were of French manufacture, and English and French engineers were present. The result was perfectly satisfactory as showing the advantage gained by the process, and proved that enormous progress had been made. The consideration for the use of the patent was a certain royalty per ton for all plates manufactured. The process is most successful with plates up to 6 in. thickness, the effect for thicker plates being not so well ascertained. Every country recognised the advantage of the new method, and, by agreement, the Russian Government works were enabled to make the new plates. The Carnegie and Bethlehem Companies obtained the rights in the United States, and in Austria the Witkowitz firm. The Terni Works, in Italy, also make a special steel which seems to be the same or closely analogous. The resistance of Krupp plates, with their hard surface, breaks up the point and head of the ogival-headed projectile, and their extreme toughness offers great resistance to punching and cracking. Results have also been attained which justify the belief that a Krupp plate is equal to a compound plate of double its thickness. It is not necessary to point out how great was the effect of this new system of hardening steel upon the protection of ships. It has enabled thinner armour to be used, and the area covered to be more extensive; and it may be said that at the present time a 12-in. gun of 50 tons fairly matches a 12-in. plate.

The plate has thus remained victorious over the projectile, and the eminent authority who

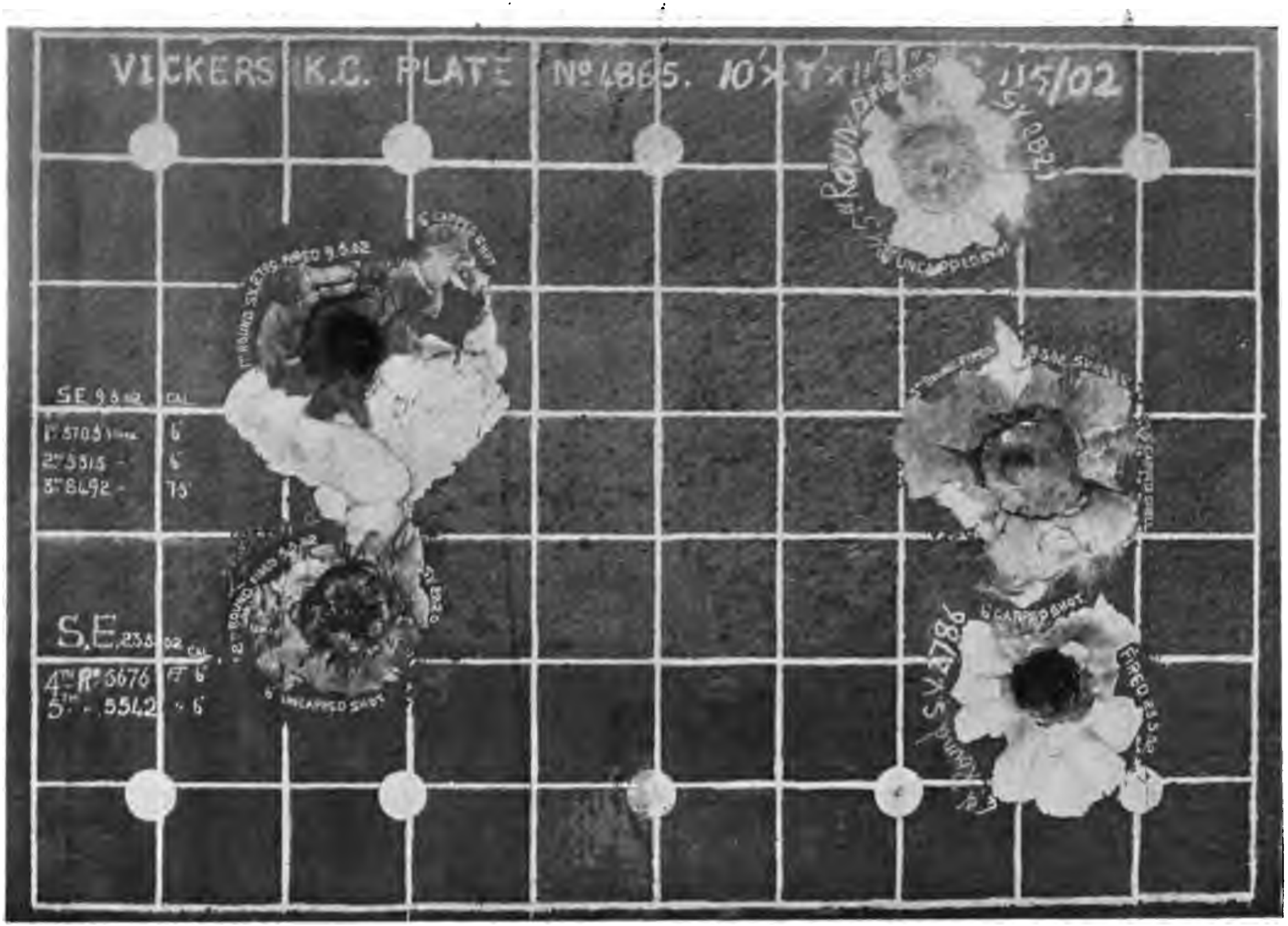
---

The following results, illustrating the advantage of the "Johnson cap," were obtained at Messrs. Vickers, Sons and Maxim's range at Eskmeals against a 12 in. Vickers K.C. plate (1,000 yds.)

(Fig. 1.) First round.—6-in. Johnson armour-piercing capped shot, weighing 105 lbs. Plate was completely perforated and projectile broken up. Penetration measured 18 in. to base of shot, but after removing its fragments the penetration measured 23⅛ in. Extent of injury by scaling, 18·5 in. H × 20·5 in. V. No cracks. Diameter of hole 6 in. This shot struck exactly in front of a horizontal H girder and bulged it back 1⅞ in., otherwise it would have gone completely through. Striking velocity, 2,799 foot-seconds: striking energy, 5,705 foot-tons.

Second round.—6-in. Johnson armour-piercing shot, without cap, weighing 100 lbs. Projectile completely broken up. Penetration about 3¾ in.; but point of shot remained fused in plate. Extent of injury by scaling 18¼ in. H × 19 in. V. No cracks. Diameter of portion of shot in hole = 8 in. There was no trace of bulge at back, or displacement of backing. Striking velocity, 2,820 foot-seconds; striking energy, 5,513 foot-tons.

Third round.—7·5 in. Johnson armour-piercing capped shell, weighing 205 lbs. Projectile broken up, but all the point portion, including 2 in. of core, remained in plate. It was not, however, fused in as in Round 2, for a feeler could be inserted in many places round the periphery up to 7 in. from face of plate. Penetration to front end of core was 5 in., if, therefore, the point preserved its profile, the total penetration would be 9½ in. Base portion set up and part flowed in molten state into the front of core, moulding itself to its contour. Extent of injury, 23·5 in. H × 21·5 in. V. Striking velocity, 2,444 foot-seconds; striking energy, 8,492 foot-tons.



FIRST ROUND
SECOND ROUND

FIFTH ROUND
THIRD ROUND
FOURTH ROUND

RESULTS OBTAINED AFTER FIFTH ROUND AGAINST A 12-IN. VICKERS K.C. PLATE, ILLUSTRATING THE ADVANTAGE OF THE "JOHNSON CAP." (FIG. 3.)

(For details see opposite page.)

the ordinary shot upon impact with a cemented plate results instantaneously with the shock, while the pressure of the cap has for its effect to give an appreciable degree of duration to the attack, thus permitting the ogival head of the projectile to reach a zone of softer metal, and to check in the projectile itself those vibrations which lead to fracture. In short, the soft cap protects the hard point of the shell, and holds it in position while its work is in progress. Admiral Makaroff, the eminent Russian officer, undertook in 1894 a series of trials with armour plates and special projectiles, which were described at the time as being manufactured by a secret process, and were called "magnetic." It was soon divined, however, that the word "magnetic" was intended to conceal their true character,. and that they were in fact capped shot. The concealment of the projectile from view suggested the application of some visible device, and screens were employed which might catch anything detached from the shot, while it was stated that the process was applied to Holtzer projectiles, a circumstance which seemed to point to a mechanical rather than a metallurgical process. The trials took place at Ochta, on June 28th, 1894, when two Harvey-Tresidder plates, 8 ft. square and 6 in. thick, were furnished severally by Brown and Cammell, and one of the same dimensions 10 in. thick by Brown. These were attacked by 6-in. projectiles from an Obukhoff 45-calibre gun, the striking velocity for the 6-in. plates being about 1,850 foot-seconds, and for the 10-in. plate 2,400 foot-seconds. Owing to the curve of the plate, the angle of impact was from 8 deg. to 10 deg. from the normal. The projectiles were made at the Putiloff works, and, while those of the ordinary class broke up, the "secret-process" or "magnetic" shot perforated the plates direct, in one case striking at about 25 deg. from the normal, though oblique impact failed against the Cammell plate. With the Brown 6-in. plate these capped shot went through in every case, though one was broken up, while the ordinary projectiles were fractured, but one of them caused five or six cracks. In the case of Cammell's 6-in. plate, two of the capped shot were pulverised, but these struck at 25 deg. from the normal. At 20 deg. one of the capped shot broke up, but penetrated to a depth of 2·3 in., and one which hit at 15 deg. went through and broke the plate. Another, within 10 deg. of the normal, completely perforated. In the attack upon Brown's 10-in. plate, two capped shots went through at 8 deg. from the normal. The cap did not, in every instance, save the shot from fracture, but the penetration was greatly increased even when it broke, and it enabled the shot to perforate treated plates in conditions in which uncapped shot were totally defeated. Trials have shown that it is difficult to depend upon the effect of capped projectiles when the impact is at a considerable angle, and if oblique fire should play a large part, it may be surmised that the application of the cap might often be ineffective.

Projectiles of this class were advocated by Mr. Hadfield, Colonel Bainbridge, and others, and it was stated on good authority that comparative tests with Wheeler and Krupp projectiles were made in Germany, and that the latter proved themselves as good as the former. Mr. Isaac G. Johnson, of Spuyten Deeyvil, U.S.A., worked out his plan with considerable success. He used a special steel, and fitted his cap to a solid projectile. On April 30th, 1896, a capped 6-in. 100-lb. shot perforated a 7-in. reforged Harveyized Carnegie plate. Other successes followed, and the trials were watched with considerable interest. In France, Holtzer and Saint-Chamond projectiles were tried, in which the cap was applied hot and shrunk on the ogival head, or mechanically attached. The "Johnson cap" has been attached by means of a groove near the point, while Messrs. Hadfield employ a rib on the shot, also near the point.

An important trial of a special Beardmore 6-in. plate at Messrs. Vickers' range in October, 1891, threw clear light upon the value of the cap, and foreshadowed the success of last May, which has been alluded to. The projectile was an Elswick armour-piercer of 100 lbs., and in

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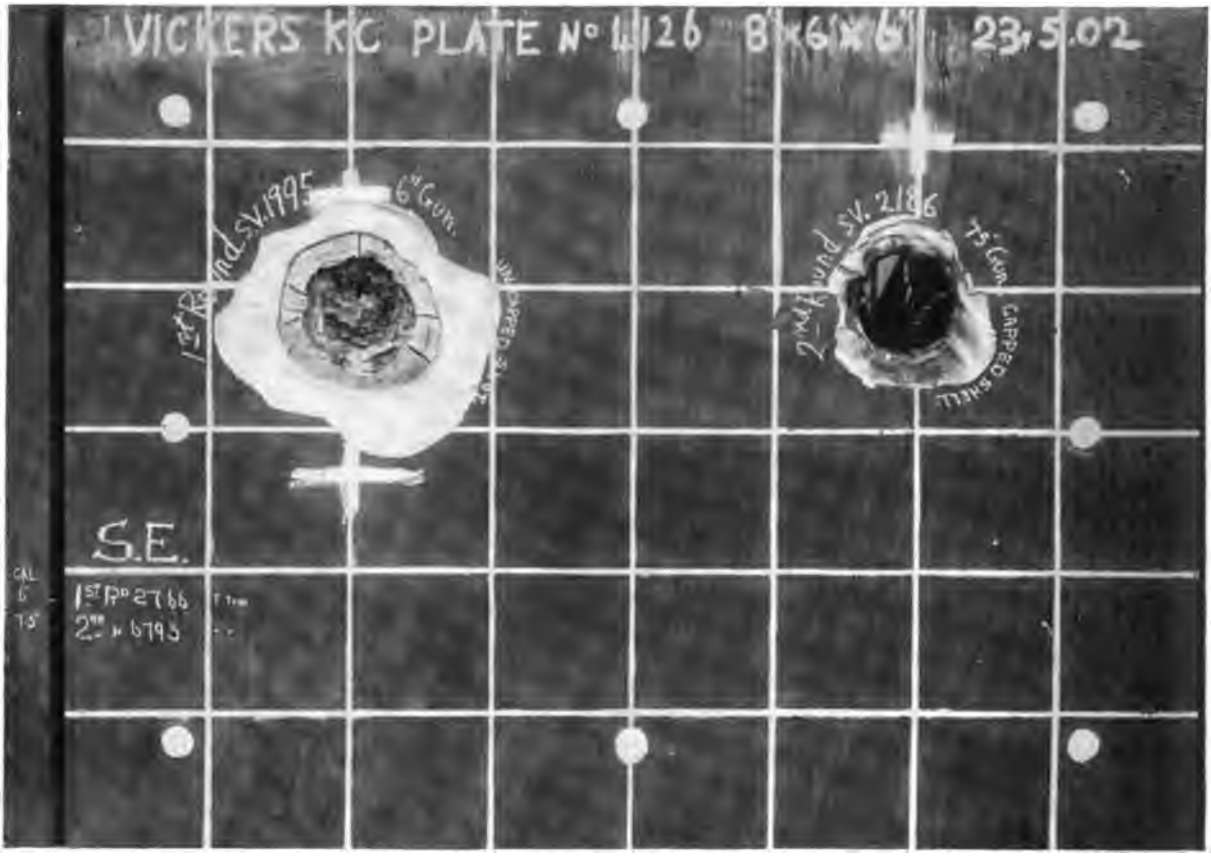
(Fig 3.) Fifth round.—6-in. Standard Firth armour-piercing shot, without cap, weighing 100 lbs. Shot completely broken up. Penetration, 3 in. Point of shot remained fused in plate. The diameter of periphery of front of projectile left in the plate was 8 in. A large piece of shot rebounded and was found 20 ft. in front of plate. Striking velocity, 2,827 foot-seconds; striking energy, 5,542 foot-tons.

NOTE.—These last two shots loosened somewhat the portion of the 7·5-in armour-piercing shell, fitted with cap, used for the third round, so that now a feeler can be inserted outside the shell for a distance of 11¾ in., showing that this capped shell must have nearly, if not quite, perforated the plate.

the first three rounds, in which the highest power resulted from a striking velocity of 2,177 foot-seconds and 3,280 foot-tons striking energy, with a penetration of wrought iron of 15·7 in. by Tresidder's formula, the projectiles were completely broken up, and no cracks resulted in the plate. In the fourth round, with a striking velocity of 2,261 foot-seconds and striking energy of 3,550 foot-tons, the point of the projectile just broke through. In the last round, with a capped projectile (105·9 lbs.), the striking velocity being reduced to 1,945 foot-seconds, the striking energy to 2,778 foot-tons, and the penetration of wrought iron to 13·8 in., the projectile completely perforated the plate undamaged, and passed through the backing to


VICKERS KC PLATE No 4126 8' x 6' x 6" 23.5.02
1st Round S.V. 1995 6" Gun
UNCAPPED SHOT
2nd Round S.V. 2186 7.5" Gun
CAPPED SHELL
S.E.
1st Rd 2766
2nd " 6793
CAL
6
7.5

FIRST ROUND SECOND ROUND

RESULTS OBTAINED AFTER A FIRST AND SECOND ROUND AGAINST A 6-IN. VICKERS K.C. PLATE, ILLUSTRATING THE ADVANTAGE OF THE "JOHNSON CAP." (FIG. 4).

First round.—A 6-in. Vickers armour-piercing shot, without cap, and weighing 100 lbs., was discharged against the above target from a 6-in. gun (Mark B), loaded with 12·5 lbs. of cordite, at a distance of 1,000 yards. It was observed that the projectile was broken up, the point remaining fused in the plate. The extent of injury by scaling was 24 in. H × 22 in. V. No cracks were formed by the impact, but signs of a bulge were discernible at the back of the plate. The muzzle velocity was 2,034 foot-seconds, striking velocity 1,995 foot-seconds, and the striking energy 2,766 foot-tons.

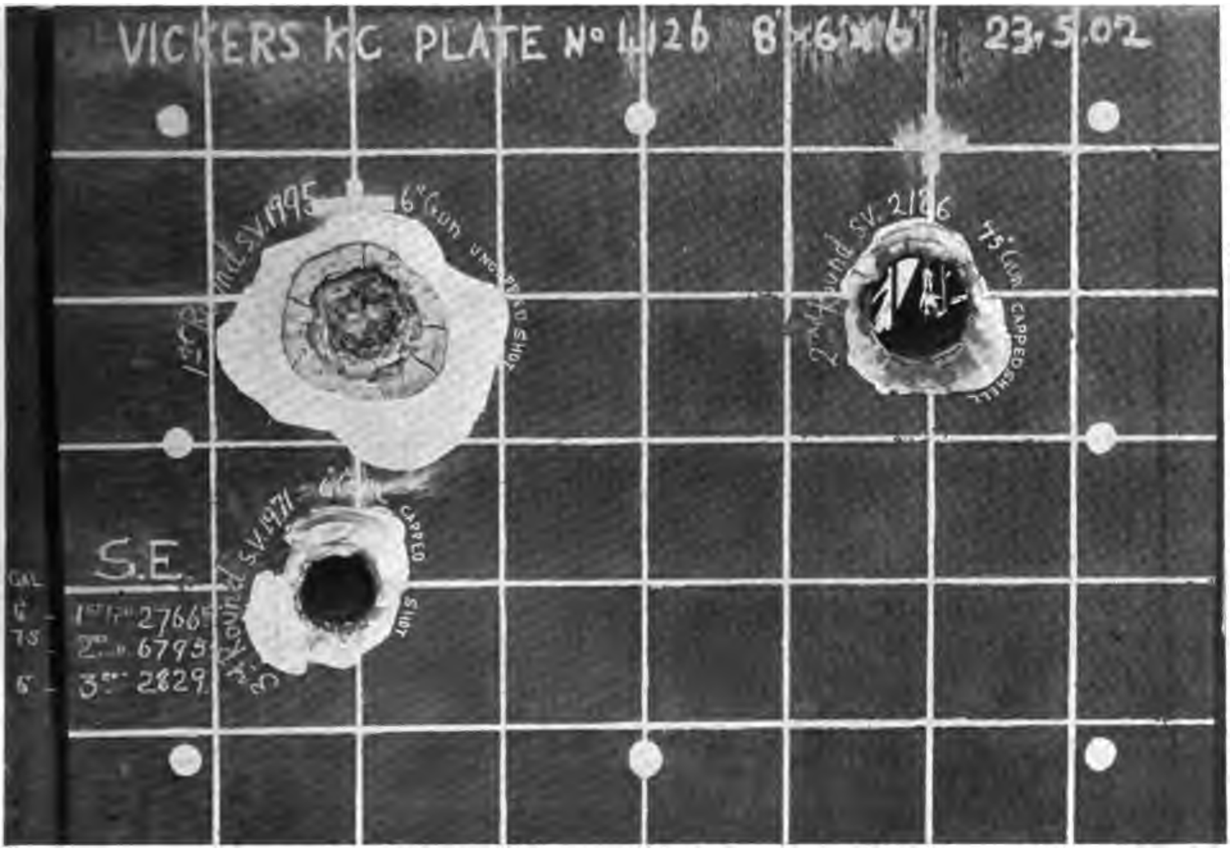
Second round.—The next attempt was very successful. A 7·5-in. armour-piercing shell, fitted with the "Johnson cap," and weighing 205 lbs., discharged at 1,000 yards from a 7·5-in. gun (50 cals.), loaded with a charge of 35·31 lbs. of cordite, not only completely perforated the plate and backing, but the point of the shell, weighing 92 lbs., penetrated 20 feet into a sand bank at the rear of the target. No fragments of the projectile, except the base plug were found, and the size of the hole in the plate measured 8·75 in. x 8·5 in. Scaling had taken place around the aperture to the extent of 14 5 in. H. x 14·5 in. V. The muzzle velocity was 2,221 foot-seconds, striking velocity 2,186 foot-seconds, and the striking energy 6,795 foot-tons.

bury itself beyond. A trial of a 6-in. Carnegie plate gave analogous results, and a capped projectile of 100 lbs., with 1,913 foot-seconds striking velocity, was found just equal to an uncapped one with 2,290 foot-seconds, and it increased the penetrating power by 25 per cent.

The following table shows the results with an 11-in. Krupp plate, manufactured by the Bethlehem Steel Company, representing turret-armour of the battleship *Maine*, which took place at Indian Head in May. They were not so conclusive in regard to the value of the capped shot.

Gun.	Projectile.	Striking velocity.	Striking energy.	Penetration.
in.	lbs.	foot-secs.	foot-tons.	in.
10	500	1,753	10,664	4·1
10	500	1,779	10,983	4·7
10	500	1,853	12,610	5$\frac{5}{16}$
12	886	1,599	15,368	3$\frac{1}{8}$
12	868	1,641	16,233	6
12	867	1,733	18,072	7 or 8

In the first three rounds with ordinary projectiles the plate was bulged, but not cracked. The other rounds were with capped projectiles—a Midvale, a Wheeler, and a Carpenter—


VICKERS KC PLATE No 4126 8'×6'×6" 23.5.02
1st Round S.V. 1995 6" Gun Uncapped Shot
2nd Round S.V. 2126 7.5" Gun Capped Shell
3rd Round S.V. 1971 6" Gun Capped Shot
S.E.
Cal.
6" 1st Rd 2766
7.5 2nd " 6795
6" 3rd 2829

FIRST ROUND SECOND ROUND
THIRD ROUND

RESULTS OBTAINED AFTER THE THIRD ROUND AGAINST A 6-IN. VICKERS K C. PLATE, ILLUSTRATING THE ADVANTAGE OF THE "JOHNSON CAP." (FIG. 5.)

Third round.—The above photo shows the aspect of the plate after the third round. A 6-in. Vickers armour-piercing shot, fitted with a "Johnson cap," and weighing 105 lbs., propelled from a 6-in. gun (Mark B) by a charge of 12·94 lbs. of cordite, completely perforated the plate and backing, as in the case of the heavier projectile. The shot, however, broke up, and pieces of it were afterwards found at the rear of the target. The size of the hole was about 6·5 in., the extent of injury by scaling being 13 in. H × 14 in. V. The mean muzzle velocity was 2,007 foot-seconds, the striking velocity 1,971 foot-seconds, and the striking energy 2,829 foot-tons.

the first of these rounds being at about 15½ deg. from the normal, and somewhat more in the case of the succeeding rounds.

An attempt has now been made to show the varying conditions which have affected the contest between the gun and the plate, giving the superiority first to the one and then to the other. It has been shown that the Krupp process has enabled the plate to triumph, but that the introduction of the cap, which is now sure to be adopted, may again shift the balance and make the contest more equal. It remains to be seen what further advance may yet be made to meet the reinforced attack.

It must be remembered, however, that the introduction of a cap is not solely a matter concerning velocity and energy. The value of a gun rests even more in its ability to direct a projectile to the point desired, and anything that changes the conditions of its external ballistics requires to be considered from another point of view entirely. It has been pointed out that the use of the cap is likely to reduce the stability of the projectile in its flight, greatly to diminish precision of fire, and to overthrow entirely existing tables of fire. In view of these considerations, the late Admiral Sampson, then a captain, an officer of great competence in ordnance matters, is said to have pronounced against the use of the cap except in special conditions. Remembering also the fact that capped projectiles are more uncertain in result as the striking angle is increased, being affected in greater degree in this regard than ordinary shot, it may be concluded that the long contest between the gun and the armour-plate will not soon be decided by the temporary victory of either of the adversaries.

How far it is from settlement may be seen by the rival claims now put forward in the United States. Ordnance and artillery officers of the Army have devised a new fuse which they declare will not detonate until after the shell has entered far into an armour plate, and it is suggested that, with the tremendous velocities now attained, and the great advances made with smokeless powder, further progress in the manufacture of plates becomes necessary. The Naval authorities recently tried an armour-piercing shell at Indian Head, for which it is claimed that it will perforate armour of a thickness equal to its own calibre, carrying a heavy charge of high explosive. A 6-in. shell is, indeed, said to have passed through a 6-in. plate, breaking up on the other side. It seems desirable, however, to receive reports of armour-piercing high explosive shells with some caution, until extended trials have demonstrated their effectiveness. Meanwhile, Lieut. Cleland Davis, U.S.N., attached to the Bureau of Ordnance, has introduced an electrical carbon treatment for armour plates, which is said to have results much superior to anything yet known. It is stated that heavy currents of electricity are directed on the plate, while it is in a heated state, by large carbon anodes. The electric current forms an arc, carrying with it a portion of the carbon of the anode to a depth regulated by the length of the application, thus rendering the plate exceedingly hard. Admiral O'Neil is believed to attach much importance to the invention, but further information regarding it is much to be desired. The process appears to give new promise to the plate. It is, at the same time, worthy of note that Lieut. Davis has himself introduced a new form of explosive shell designed to increase the capacity for a bursting charge, and to add to the perforating power by concentrating the weight in the line of attack—in other words, to strengthen the walls of the shell in order to resist fracture.

THE DEVELOPMENT OF "WIRELESS" TELEGRAPHY.

BY

H. C. MARILLIER.

II.

MARCONI'S SYSTEM.

IN the annals of "Wireless" Telegraphy the year 1896 is memorable for the arrival on the scene of Mr. Marconi, a young Italian, who came to this country armed with a patent which he had provisionally applied for, and with an apparatus which he had been testing for a year previously near Bologna. The British Post Office, represented by Mr. (now Sir) William Preece, and the Royal Engineers, were conducting experiments on Salisbury Plain, and Mr. Marconi had no difficulty in obtaining an invitation to exhibit his system. Signals were exchanged across a valley one and a-half miles wide, and the results were promising enough to warrant more extended trials, which were carried out under the auspices of the Post Office at Penarth and elsewhere. Mr. Marconi at this date was using a very simple apparatus, based upon the elements generally employed in Hertzian experiments; and his own contributions to it appear to have consisted mainly in earthing one pole each of the transmitter and coherer, introducing choking coils into the receiving circuit, and laying down a hypothetical law of squares as representing the relation between the height at which he placed his "capacities"—cubes of metal, probably biscuit boxes in the first instance—and the space over which signals could be detected.

Lafayette, London.]

GUGLIELMO MARCONI.

Mr. Marconi, however, possessed a quality of energy which was worth more than his original apparatus, and owing to this, and the favourable circumstances which have enabled him to carry out costly experiments on a large scale, he has gone on adding continual and real improvements to the system, and has succeeded in monopolising to a large extent its commercial possibilities. Indeed, on the practical side, he has had no rival so far but Professor Slaby, in Germany, whose work will be dealt with later, and in point of record accomplishment he has left Professor Slaby, as well as others, far behind. The public has a weakness for records, and Mr. Marconi's work has thus attracted an overwhelming share of popular attention. This in its turn has produced counter-attentions of an opposite character, and has led Mr. Marconi into controversial discussions as to the originality of his system and the value of what he has done. With regard to the latter, let it be admitted that he has taken a leading part in bringing "wireless" telegraphy into practical use. He has foreseen and forestalled its most useful applications. With apparently unlimited resourcefulness, working from short, up to gradually longer distances, he has erected station after station in remote and often uncongenial localities. He has spent weeks at a time at sea testing and improving the details of his receiving instruments. He has tried every known kind of apparatus, modifying it to suit his own needs, and has introduced methods of working that were unknown. In fine, nothing has damped his pertinacity or self-confidence, and these qualities, though scarcely of an ingratiating kind, do not fail to appeal to Anglo-Saxons, who never withhold tribute from the man who succeeds.

MARCONI'S CLAIMS TO ORIGINALITY.

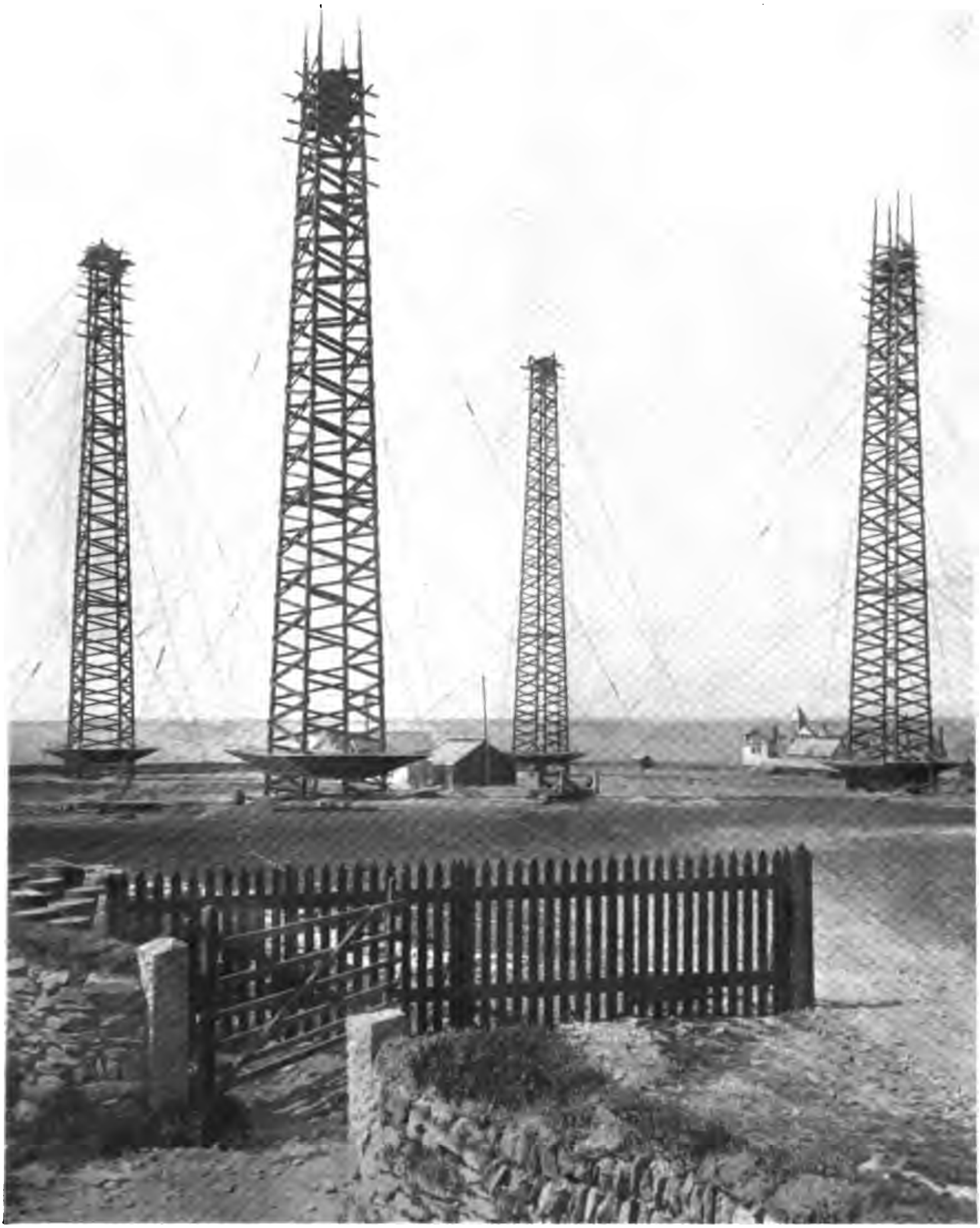
On the other hand, it is easy to overrate the originality of (at any rate) Marconi's earliest work, on which he stepped into fame, and gushing writers for the press have habitually done so, with the result that certain men of science have been driven into an opposite camp, and have accused Mr. Marconi of suppressing in his papers the credit due to others. His first patent, already mentioned, lends some colour to their view. Under the comprehensive title of "my invention" it sets forth a number of things which were pretty well known before, and were certainly not invented by Mr. Marconi. Its claims embrace, for instance, Righi's oscillator, Lodge's "antennæ," Lodge's tapper worked by a relay, Branly's and Lodge's coherers, Righi's detector for fixing the proper length of the "antennæ," Hertz's parabolic reflector, and other similar devices. It does not claim the long vertical wires which were really the secret of Marconi's success, possibly because Edison had previously used and patented the same idea.

HIS FIRST APPARATUS.

In the *Strand Magazine* for March, 1897, there is an illustrated interview with Mr. Marconi (an unusually fulsome production), which, at all events, contains one item of interest. This is a portrait of the inventor seated before his early apparatus. On one side is what appears to be an ordinary Righi oscillator, on the other a box containing the coherer and battery, with horizontal "antennæ," or copper strips, such as Lodge first used for tuning and strengthening the coherer circuit. On top of the box is a telegraphic instrument worked by the relay inside. There is no element of novelty in this apparatus, and on the face of it no special modifications. One may fairly suppose that Mr. Marconi, either from inexperience in drafting a patent, or from the difficulty of describing his arrangements without specifying all the apparatus used, was led to include much that he had found ready to his hand when he began working at the subject. Having cleared the ground on this point, we can leave Marconi's first patent, which contains very little that is now of value, and trace the course of his subsequent

MODIFICATIONS AND IMPROVEMENTS.

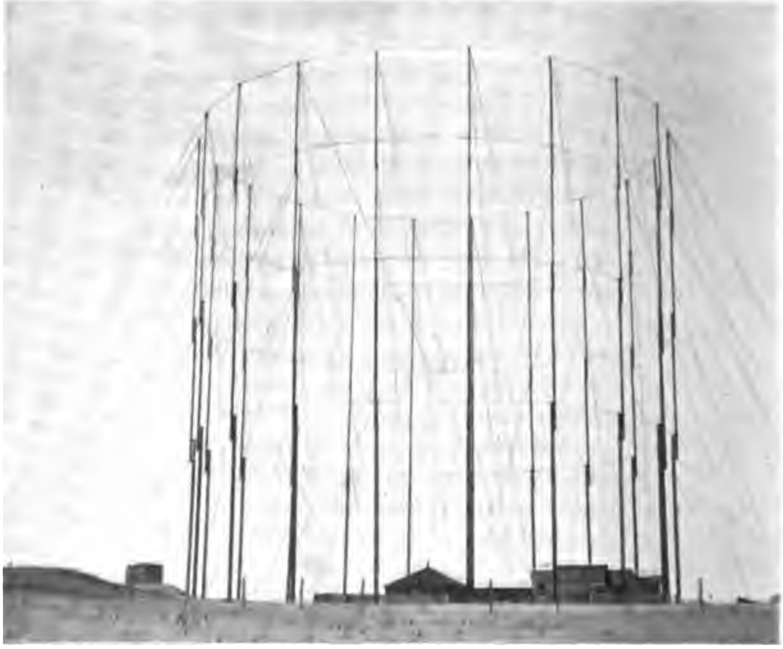
In 1898, Mr. Marconi broke off from the Post Office, and joined a company formed to exploit his system. He began by erecting a station at the Needles, Alum Bay, in which "capacities," parabolic reflectors, etc., were more or less discarded, and in which the principal feature was a long insulated wire, suspended from a mast. This was connected at the lower end to one of the ball terminals of a 10-in. induction coil, worked by a battery of 100 cells, partly in parallel, the other terminal of the coil being connected to earth. A press-down key enabled the circuit to be made and broken for longer or shorter intervals. Signals were sent to a receiving instrument on a small steamer out at sea, the vertical wire being in this case used as a collector. As soon as results warranted it, a corresponding station was erected at Bourne-



MARCONI STATION AT POLDHU, CORNWALL.

MARCONI INSTALLATION AT MAHUKONA, HAWAII.

mouth, 14 miles distant across the Solent, and later at Poole, 4 miles further still. The receiving apparatus was that already mentioned, consisting of the vertical wire (or "aerial") connected to one terminal of a metal-filings coherer, the other terminal being connected to earth. Arranged in shunt across the coherer was a circuit containing a single cell and a relay instrument, which actuated a second system, in which was a stronger battery and a Morse recorder. The relay also worked the tapper, which was an electric bell vibrating against the coherer. Choking coils and condensers were included at various parts of the circuit. The receiving apparatus was securely enclosed in a metal box (such as Branly had found necessary) to protect it from the adjacent transmitting apparatus, and only became effective when the vertical wire was switched on to it, thus enabling Hertzian waves to penetrate the screen. With the "aerial" connected at one station to the transmitter and at the other to the receiver, signals were sent from the former by depressing the key so as to form Morse code letters. The surgings set up in the wire were communicated as waves to the ether, and spread out in every direction like concentric ripples at the speed of light. When these cut the vertical wire of the receiving station, corresponding surgings (but faint in proportion to the distance) were set up in that. These were communicated to the coherer, with the result that it became a partial conductor, allowing sufficient current to pass from the single cell to operate the relay, which in turn operated the Morse inker. At the same time the tapper was set in motion, so as to "decohere" the coherer and render it sensitive once more. The action between coherer and tapper being very rapid, it hardly affects the heavy working of the Morse instrument, which there-

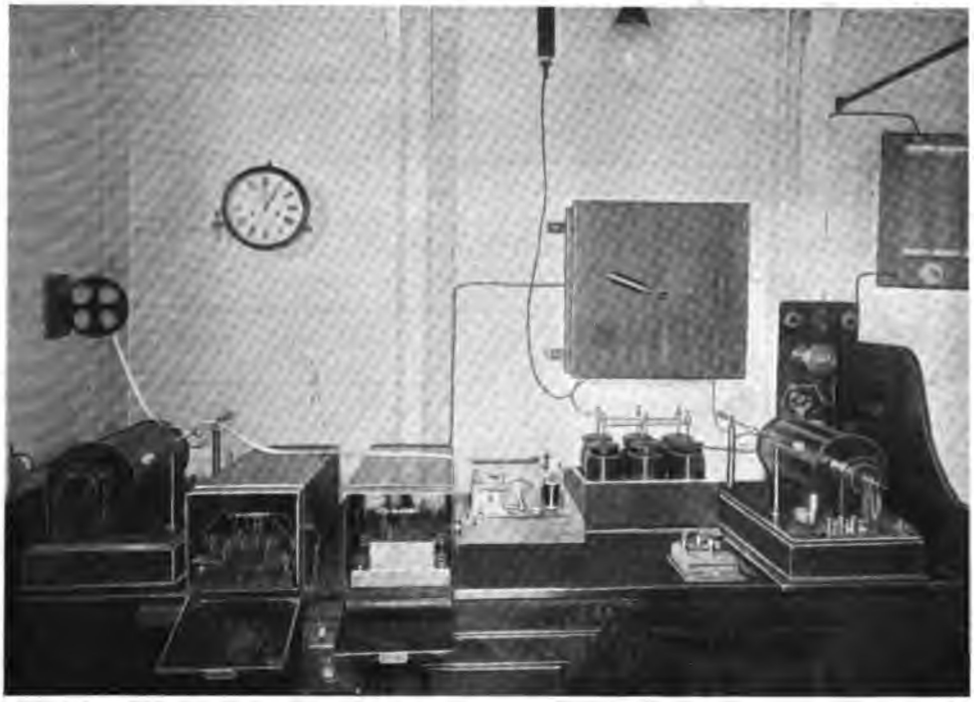


MARCONI STATION AT CAPE COD BEFORE IT WAS WRECKED.

fore registers true dots and dashes corresponding to the working of the key at the transmitting station. Mr. Marconi described this system fully in a paper read before the Institution of Electrical Engineers in March, 1899, and recorded the work achieved with it, which included reporting the yacht races in Kingstown Harbour from a steamer, in 1898, and establishing communication between Osborne House and the Royal yacht *Osborne* during the cruise of H.R.H. the Prince of Wales, at the time that he was suffering from a fractured patella.

TUNING THE CIRCUITS.

The chief defect in the system at this time, and it was a serious one, was the absence of any device for tuning or screening the circuits, and Marconi's subsequent patents and experiments were mainly devoted to this necessary end. His first arrangement, patented June 1st, 1898, was the device known in Marconi language as the "jigger." The vertical wire was no longer insulated, but connected to earth direct through the primary of an induction coil. The coherer, with a condenser in the circuit, was placed across the terminals of the secondary. Coil and condenser were constructed so as to be "in tune or symphony" with the particular oscillations given off by the transmitter. In a discourse delivered at the Royal Institution, November, 1900, Mr. Marconi, curiously enough, says nothing about this use of the transformer, but confines himself to its power of reinforcing the faint oscillations received, and so extending the range of signals. He says :—



MARCONI INSTRUMENT ROOM ON BOARD S.S. "MINNETONKA."

> The object of this transformer is to increase the E.M.F. of the induced oscillations at the terminals of the coherer, and therefore cause it to break down with a weaker oscillation, and so be affected at a much greater distance than would be possible if it were connected directly to the vertical conductor. . . . The results given by some of these induction coils have been remarkable. During the naval manœuvres I had an opportunity of testing how much they increased the range of signalling with a given amount of energy and height. When working between the cruisers *Juno* and *Europa*, I ascertained that when the induction coil was omitted from the receiver the limit distance obtainable was seven miles, but with an induction coil similar to that shown, a distance of over sixty miles could be obtained with certainty.

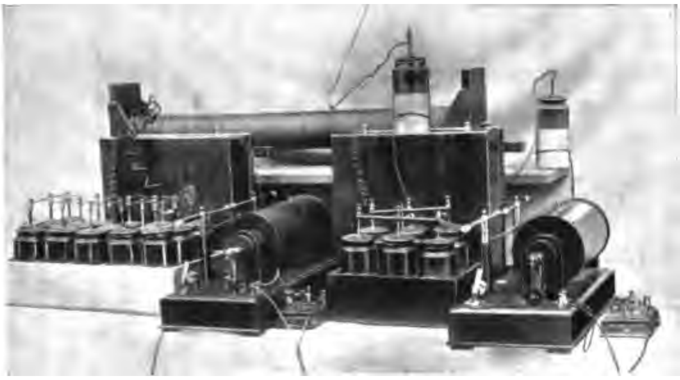


FIG. I. MARCONI TRANSMITTER, WITH DOUBLE SYNTONISING COIL.

In the interesting series of experiments carried out between South Foreland and Wimereux, near Boulogne, in 1899, this device was constantly employed. A permanent installation had been fitted up at the same time between the South Foreland Station and one of the lightships on the Goodwins, and Mr. Marconi was understood at the time to claim that signals from the lightship did not clash with or confuse the signals from Wimereux.

PROBLEMS IN SYNTONIC EFFECTS.

The *selective* properties of the "jigger" were set forth in a subsequent paper of May 15th, 1901, read before the Society of Arts, and entitled "Syntonic Wireless Telegraphy." In this paper various methods of tuning the circuits at the different stations were described, beginning with the one referred to. Mr. Marconi described it as "the introduction of a proper form of oscillation transformer in conjunction with a condenser so as to form a resonator tuned to respond best to waves given out by a given length of aerial wire." He then went on to explain that a vertical wire pure and simple is a bad form of radiator for syntonic effects. A vertical wire discharges all its energy in one or two violent oscillations, whereas what is required is a persistent radiator, one which will give a more prolonged series of timed oscillations, the effect of which on a distant resonator will be cumulative, like the timed pulls on a heavy bell. A violent and quick radiator may affect all sorts of receivers, however tuned; but a persistent and less violent radiator will only affect the particular receiver which is tuned to it, because the oscillations given out are too feeble individually to affect others. Mr. Marconi offers two main solutions of this problem. The first is to use "an ordinary vertical radiator placed near an earthed conductor, the effect of which is to increase the capacity of the radiating wire without increasing its radiative power." By making the two conductors unequal in length a difference in phase of the oscillations was obtained, "otherwise their mutual effect would be to neutralise one another." The second solution was considered at the time more important. In it the radiating and resonating conductors take a cylindrical form, the earthed cylinder being one inside the other. The large capacity of the receiver, it is claimed, causes it to be a resonator possessing a decided period of its own, so that it is no longer apt to respond to frequencies which differ from its own period of electrical oscillation, nor to be interfered with by the stray ether waves which in summer especially render "wireless" telegraphy uncertain. Cylinders 7 metres high and 1½ metres in diameter, made of zinc, were used, and are stated to have worked successfully and without interruption from neighbouring stations between Poole and St. Catherine's Bay, Isle of Wight.

Mr. Marconi claims in his paper that this arrangement is protected by his patent of March 21st, 1900, No. 5,387, but reference to this patent shows that it is for a concentric cable, or pair of vertical conductors, which should in any case be of considerable length, and the tuning is effected by the use of inductance coils. At the transmitting station a coil of variable inductance is used in circuit with one of the conductors, and at each receiving station a similar coil, but of fixed inductance, in circuit between the coherer and one of the conductors. The inductance of the coil at the transmitting station is varied so as to be in tune with any desired receiving station.

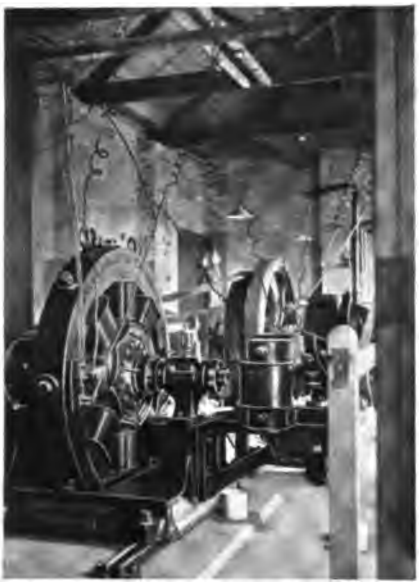
This is similar, though by no means identical, with a further system described in the Society of Arts paper, and claimed as patented April 26th, 1900, in which a single vertical wire is used, and the tuning is effected by a closed condenser circuit, such as was devised by Sir Oliver Lodge in his syntonic Leyden jar experiments. The transmitter consists of a variable condenser in circuit with a Tesla coil or transformer, and the vertical wire is made to correspond with this in period by adding or taking away length. In the receiver, the vertical conductor is connected to earth through the primary of an induction coil as before, and the coherer completes the secondary circuit, but has an adjustable condenser shunted across its terminals. In order to get the best results, the period of oscillation of the vertical wire, transformer primary, and earth connection should be in resonance with the secondary circuit which includes the condenser. The condenser "increases the capacity of the secondary resonating circuit of the transformer, and in the case of a large series of feeble, but properly timed oscillations being received, the same is summed up until the E.M.F. at the terminals and the coherer is sufficient to break down its insulation."

SIMULTANEOUS MESSAGES.

With this system Mr. Marconi claims to be able to transmit multiple messages from one vertical wire, by means of differently tuned circuits, each of which will communicate with one particular receiving station similarly tuned, and with no other. Professor Fleming vouches for the accuracy of this claim, but I am not aware of the extent to which it has been tried. Fig. 1 shows a duplicate transmitting apparatus in which selective tuning is got by dividing the long coil shown into two unequal parts, corresponding with the receiving apparatus at two different stations. This apparatus has been demonstrated to various Government officials; but, so far as I know, it is not yet in permanent use. Syntonic apparatus on the principle just described is, however, commonly installed by the Marconi Company now, and syntonic messages have been successfully exchanged with an American liner up to a considerable distance, the same being imperceptible to a second liner following in the wake of the first.

TRANSATLANTIC COMMUNICATION.

Mr. Marconi's most recent work has been in the direction of establishing Transatlantic communication, and his results have been so widely published that there is no need to dilate on them here. The apparatus used in these experiments has not been described, but it is known to differ very considerably from anything Mr. Marconi has used before, and the small photograph of the interior of the Poldhu station in Cornwall, which Mr. Marconi has built for these experiments, shows that an alternator of very considerable size is required. This, if report speaks accurately, generates a continuous high-tension Tesla discharge, which is interrupted by means of a magnetic, or more probably a mechanical, blower. The radiator consisted, in the first instance, of 50 naked wire conductors suspended from a horizontal wire rope joining the top of two masts, each 48 metres high, and converging to a common centre. A corresponding station at Cape Cod, Mass., U.S.A., had the conductors suspended from a circular ring joining the tops of a great circle of masts (see illustration), but both stations were unfortunately wrecked by a storm within a short time of each other. A new station is being erected at Poldhu, with four towers of scantling arranged in a square (see illustration), to carry the vertical radiators, which will hang from wires joining the tops of the towers and will meet at a common centre. Similar stations are also being put up in America and in Canada, the Government of


ALTERNATOR, POLDHU STATION.

which has subsidised the experiment to the extent of £16,000.

The signals received across the Atlantic by Mr. Marconi (the letter "S" repeated) were transmitted from Poldhu to a temporary station in Newfoundland, where the vertical wires were suspended from a balloon or kite. The constantly changing capacity of this conductor made the ordinary Marconi system unworkable, and the signals were received on a telephone by means of a mercury coherer, invented by a signalman in the Italian navy named Castelli. There has been a good deal of discussion in the technical press over the merits of this invention and over certain rival claims to it; and Mr. Marconi has been extensively attacked for not mentioning the apparatus in reporting his experiments, as well as for (apparently) patenting it first in his own and then in a rival claimant's name. The mercury coherer, consisting of a globule of mercury between an iron and a carbon plug, possesses a far higher degree of sensitiveness than the ordinary metal filings coherer, and is self-recovering. Mercury for this purpose has been proposed long ago, both by Professor Chunder Bose, of Calcutta, whose advanced and early researches call for further mention hereafter, and also by Mr. Appleyard; but this is the first time it has been practically applied.

MARCONI'S NEW RECEIVER.

Since the episode above referred to, Mr. Marconi has brought out a newer, and, it is claimed, still more sensitive, receiver, based upon the known fact that electric waves will magnetise and demagnetise a steel needle. The apparatus was fully described in a paper read before the Royal Society, June 12th, 1902. Its construction is as follows:—

On a core consisting of thin iron wires are wound one or two layers of fine insulated copper wire. Over this winding insulating material is placed, and over this again another longer winding of thin copper wire. The ends of the winding nearest the iron core are connected to the plates or wires of the resonator, or, as is the usual practice in Marconi long-distance telegraphy, to earth and to an elevated conductor; or they may be connected to the secondary of a suitable receiving transformer or intensifying coil, such as are employed for syntonic wireless telegraphy. The ends of the other winding are connected to the terminals of a telephone or other receiving instrument. Near the ends of the core is placed a magnet, revolved by a clockwork arrangement, so as to cause a slow and constant change, or successive reversals, in the magnetisation of the iron core. If electrical oscillations of suitable period be sent from a transmitter, rapid changes are effected in the magnetisation of the iron wires, and these changes cause induced currents in the windings, which in turn reproduce on the telephone the signals sent from the transmitting station. Should the magnet be taken away, or its movement stopped, the receiver ceases to be perceptibly affected by the electric waves.

The phenomenon exhibited by this apparatus appears to be a change in "lag" or magnetic hysteresis caused by the incidence of the waves on a body subjected to a varying magnetic field. The rapid alterations of molecular strain can be detected by a telephone. Mr. Marconi claims for his new receiver that it possesses a practically uniform and constant resistance much lower than that of a coherer in its sensitive condition, also that it will work with a much lower E.M.F. Its usefulness, however, has still to be tested.

Mr. Marconi's system has had the advantage of extensive trials in the navies both of Great Britain and Italy and in the mercantile marine. One of our illustrations shows the arrangement of the apparatus on board S.S. *Minnetonka*, the latest vessel to be so fitted up. Another illustration shows one of the masts erected in the Hawaiian group of islands by a private company for inter-insular communication. The venture has, for some reason, broken down, but there is some talk of restoring it. Marconi apparatus was also tried in the South African War without great success, owing, as Mr. Marconi himself says, to want of masts and proper conditions of working. The system (speaking of "wireless" telegraphy in general) certainly seems more adapted for sea than for land communication,* and is likely to come into common use on ships. It is already installed at many of the Lloyds' calling stations, the Marconi Company having succeeded in getting a fourteen years' monopoly from the Corporation of Lloyds.

In the next article we shall deal with a number of inventors whose work has not yet attained the range or the prominence of Marconi's, but who have, nevertheless, contributed to the development of "wireless" telegraphy, and who may presently come forward as rivals in the field.

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* The Orling-Armstrong and other earth-current systems are, of course, an exception to this rule.

THE LARGEST SUSPENSION BRIDGE IN THE WORLD, AS IT WILL APPEAR WHEN COMPLETED.

THE WORLD'S GREATEST SUSPENSION BRIDGE.

BY

W. B. NORTHROP.

BETWEEN New York and Brooklyn cities there is now being built the largest highway suspension structure in the world. Already the making of the great suspension cables has begun, and the work is progressing at a rate which assures the completion of the bridge in about two years.

This bridge will cost, for the structure alone, about £1,600,000, and including the money which must be paid out for the right of way over certain city property, £2,700,000.

Compared with some of the present big bridges of the world, the New East River Bridge takes easy precedence. The centre span is 1,600 ft., 5 ft. longer than the Brooklyn Bridge, 320 ft. longer than the famous bridge at Clinton, Canada, and 780 ft. longer than the suspension bridge over Niagara River, near the Falls. On completion it will connect one of the most densely populated districts of New York city with one of the largest thoroughfares of Brooklyn. The bridge will span the East River between Delancy Street, New York, and South Sixth Street, Brooklyn. Delancy Street is very near Grand Street, on the New York side, while South Sixth Street is but one block north of Broadway, Brooklyn.

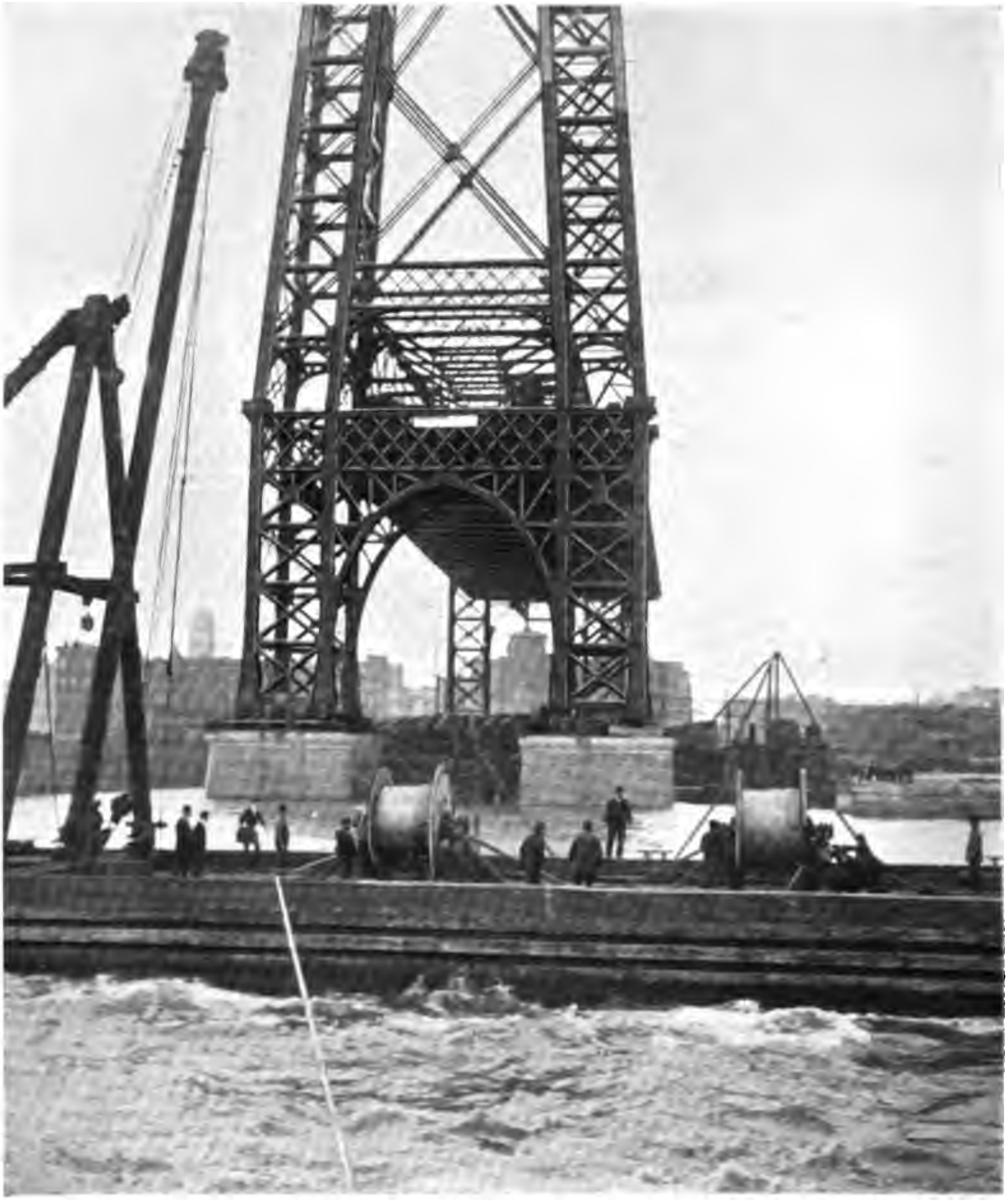
The total length of the new bridge, including spans and approaches, will be 7,200 ft., the approaches on both sides being about 1,200 ft. longer than those of the present Brooklyn Bridge.

Between the Brooklyn Bridge and the New East River Bridge will exist a strong family resemblance. The towers of the former, however, are composed of stone, while those of the latter are of iron.

When it was first proposed to throw a span of iron across the East River, in 1870, at the time of the projection of the Brooklyn Bridge, the plan was considered by many to be utterly impracticable. Engineering authorities laughed the project to scorn, while the general public regarded it as altogether chimerical.

It was only after the Brooklyn Bridge had been subjected to years of severe straining that the public felt assurance in patronising it. Even when it was proposed, a few years ago, to run two additional lines of cars on the outer roadway, it was suggested that the bridge was not sufficiently strong to bear the weight.

To show the advancement in ideas since the building of the Brooklyn Bridge, it may be stated that not a question has been raised as to the mechanical possibilities of the present project. Everyone in America regards it as a matter of course, and some even imagine the new bridge will bear ten times more weight than will actually be put upon it.



STRETCHING THE FIRST CABLE FROM NEW YORK TO THE BROOKLYN TOWER.

PRELIMINARY WORK.

A great deal of preliminary work had to be done before a suitable site could be found, where the water would not be too deep, and where the bed on which the foundations were to rest would be sufficiently firm. Exactly similar points had to be chosen on both the New York and Brooklyn sides of the East River.

The first step in the construction of the new bridge was the sinking of immense caissons. The caisson is built according to the depth of water in which it must operate. On the New York side this depth was but 20 ft., the principal caisson having been 28 ft. high, 63 ft. wide, and 79 ft. long. It weighed 1,400 tons. Its sides were of 14-in. timber, the interior being of southern pine, planed and squared, and covered by an additional planking 2 in. thick, tongued and grooved together. The caisson was caulked thoroughly and tarred throughout.

Men who work in caissons under the beds of rivers are called "Sand Hogs." Each gang has two "shifts" of four hours' duration. "Sand Hogs" receive about eighteen shillings a shift for their wages. Where the depth is very great the men labour at much physical disadvantage. Their wages are, in consequence, proportionately higher. Some only remain down about ninety minutes, this securing them a day's pay.

The main danger to caisson workers comes from passing too quickly through the air locks. Of course, as one descends towards the river bed the atmospheric pressure increases. If one goes through an air lock too quickly the sudden increase or decrease of pressure will affect the lungs and heart. If the workman neglects to take proper rest after caisson work, he gets a strange malady called by the men "bend." It is a species of paralysis which often terminates fatally.

FOUNDATIONS IN DEEP WATER.

When the sand in the air chamber has been removed to a sufficient depth and the bed rock is reached, the laying of the foundation-stones of the bridge proper on the bed of the river is commenced.

Though the depth of water on the New York side was but little, that on the Brooklyn end was more than 100 ft. Some parts of the work were carried on at a depth of 105 ft.—within 15 ft. of the depth beyond which it is impossible for human beings to do this class of work. At 120 ft. below the surface there is a pressure of 57·77 lbs. per square inch, as against a normal pressure of 15 lbs. per square inch, and at this great depth it is fatal to stay for more than five minutes.

STRENGTH, MATERIALS, AND DIMENSIONS.

The new bridge will be four times as strong as Brooklyn Bridge, and yet the material in the old bridge is far more massive. The weight on

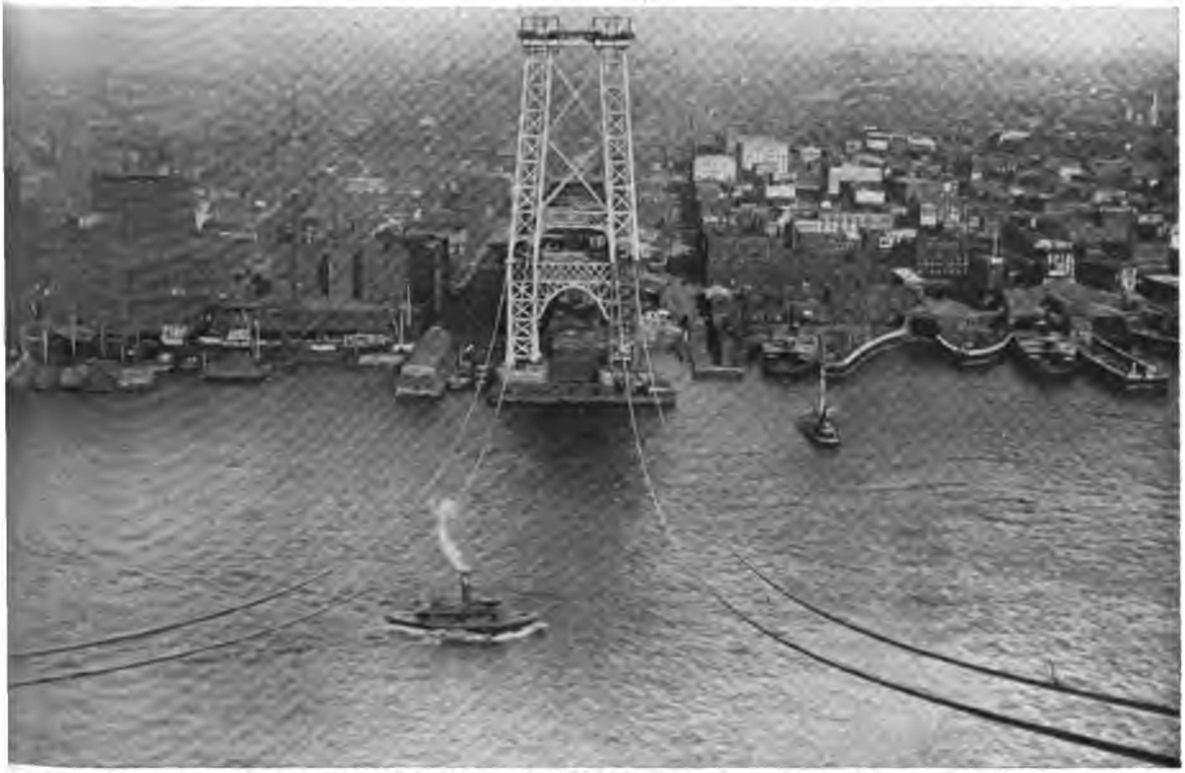
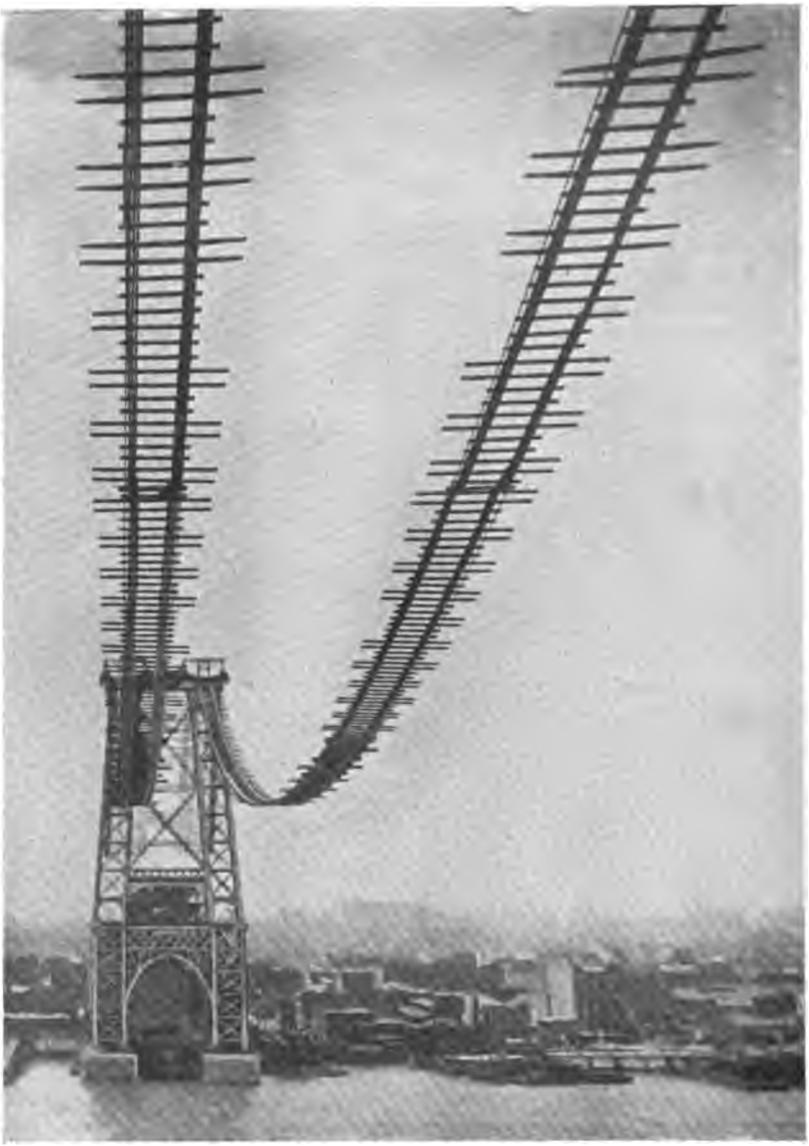


PHOTO TAKEN FROM ABOVE CABLES BEFORE COMMENCEMENT OF FOOT-BRIDGE.



LOOKING UP AT FOOT-BRIDGE.

the tower foundations of the Brooklyn Bridge is 100,000 tons, while that on the foundations of the new bridge is but 30,000 tons. The difference is owing to the use of steel for the towers of the new bridge, as already mentioned.

The width of the bridge will be 118 ft.—33 ft. wider than Brooklyn Bridge. It will carry six railway tracks, as against four of the old bridge, and there will be two wide roadways.

The enormous gain in strength of the new bridge over the old is due to the fact that the cables of the former are to be used solely for supporting the span which depends over the river. In the Brooklyn Bridge, however, the cables support both the land spans and river spans. The shore, or land, spans of the new bridge are supported partly by the anchorage and partly by intermediate towers, placed between the anchorages and towers of the suspension portion of the bridge.

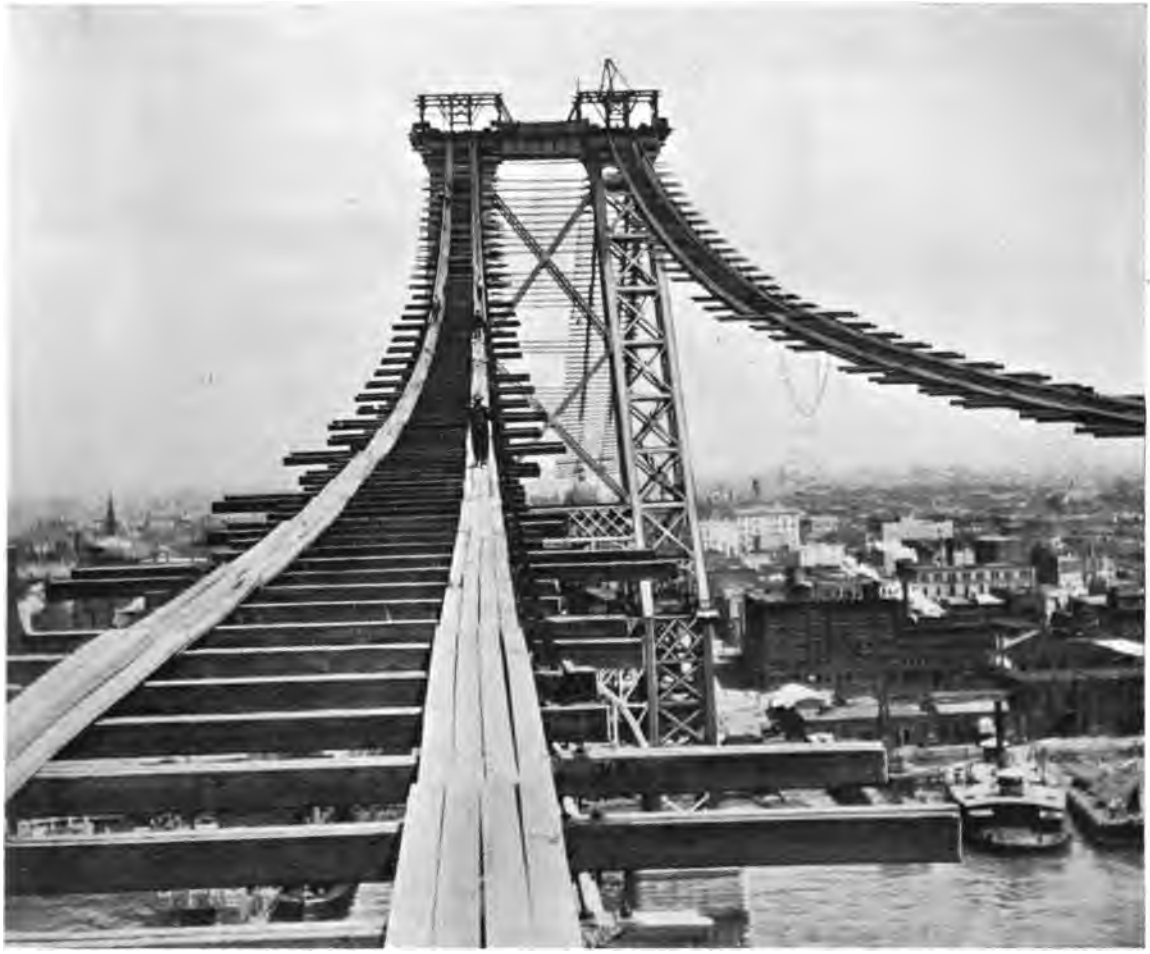


PHOTO TAKEN FROM CENTRE OF FOOT-BRIDGE, LOOKING WEST, TOWARDS BROOKLYN.

All the cables will have to do in the new bridge will be to support the 1,600-ft. span which stretches across the river at an elevation of 135 ft.—at its lowest point—above the surface of the water. This height will only be attained at the central point of the bridge, however, the whole suspension portion of the bridge forming a graceful, though gentle, arc. At the land end of the suspension on each side of the river the height will be only 117 ft.

The steel towers of the new bridge are 333 ft. high. The towers and land spans required 12,000 tons of steel in their building. Each tower, taken separately, weighs 3,000 tons.

GENERAL FEATURES.

The bridge itself will consist of four cables, with two trusses. Each cable will have 37 strands, each strand consisting of 281 wires. This will make 10,397 wires to each cable. The diameter of each cable will be 18¼ in. The wire in the bridge will have a tensile strength of 200,000 lbs. per square inch. These wires will have to bear the weight of the bridge proper, which will exert a pull of 20,000 tons on the wires. All of this weight will be borne by the anchorages on each side of the immense structure. These anchorages are made of massive blocks of stone, each anchorage containing 45,000 cubic yards of material. In the entire bridge, when completed, there will have been used 6,500,000 ft. of timber, 130,000 cubic yards of masonry, and 45,000 tons of steel. The work will necessitate excavation of 125,000 cubic yards of material, and the destruction of more than 500 buildings.

ON THE CENTRE OF THE FOOT-BRIDGE—A PERILOUS POST.

The new bridge is one-sixth longer than the Brooklyn Bridge, and its average width is 40 per cent. greater than the older structure. In its great breadth of 118 ft. it will accommodate two carriage-ways, each 20 ft. wide. In addition, there will be two lines for elevated railway trains and four tracks for surface cars, all of which will be run by electricity. Two footwalks, each 12 ft. wide, and two bicycle paths, each 7 ft. wide, will occupy a place just above the electric surface car tracks.

Five hundred men have been kept constantly employed on the New East River Bridge almost since the day the work began. This figure refers to men actually employed in the work; not to that large additional number working in the various steel mills turning out portions of the super-structure.

Now that the foundations, supports, land spans, steel towers, and anchorages are finished the work of the men is centred on the construction of an elaborate foot-bridge.

The foot-bridge in question has taken three months to build, and has cost about £40,000. It is only temporary; its object is to afford the men a foothold while engaged in the process technically called "cable making."

The foot-bridge consists of twelve 2¼-in. cables, arranged in four groups of three each. Each cable is about 4,000 ft. long, and stretches from the anchorage on one side of the river to that on the other.

The process of throwing even these small cables for the foot-bridge from tower to tower was by no means an easy task. There is so much traffic on the East River, New York, that the work of stretching the first set of cables had to be done with great rapidity. As a matter of fact, it was accomplished in something under twenty minutes. There were several large bets lost in New York on the day the cables were stretched, many believing the work would take at least half a day.

HOW THE FIRST CABLE WAS STRETCHED.

On the morning set for the stretching of the first cable between the towers—April 11th, 1901—a large barge was towed to the base of one of the steel towers. On this barge was a reel containing the cable. One end of the cable was hitched to a wire rope and hauled up over the steel tower. It was then passed back to the anchorage, where it was made fast. A tug-boat then pulled the barge out across the river. As the barge passed away from the tower, the reel with the cable unwound. The wire was allowed to sink to the bottom of the river. This prevented the cable from interfering with river traffic. The cable rested on the bottom of the river until the engineers were ready to haul the end of it up to the tower on the side of the river opposite to that on which the first end had been made fast.

The four cables were all hauled up in this manner. The foot-bridge subsequently built was put up through the agency of a number of travelling platforms, called "buggies," which hung down from the cables. Men on these "buggies" laid the planking of the foot-bridge. The "buggies" moved along each day as the work progressed.

When the foot-bridge is completed, the making of the cables proper begins. Guide wires are first laid between the towers, so that the workmen can tell just how much the big cable should "sag," or drop down, in the middle.

The main cables will be made up of 8,000 miles of fine wire. This wire will be wound back and forth across the river, just as a skein of thread is wound between the two hands. As has been said, the cables will be divided into strands, each strand having 281 wires, each cable having 37 strands. Each wire making up the cables is carried over the towers, resting on great saddles, one saddle being on the top of each tower. As each strand of 281 wires is made up, it is held together by temporary steel bands, put on the cables at certain distances along their entire length. On the making up of the complete cable of 10,397 wires, the temporary steel bands are removed and permanent bands are put in their place. These bands are of cast steel, and will encircle the entire cable. From them will hang down wire ropes, or "suspenders," which will hold up the floor beams of the bridge proper.

After all the bands have been put on the cable, the latter will be covered by steel shields, each shield overlapping the other in such a way as to shed water. It is noteworthy that all the wires in the four cables will form one continuous coil. Each coil will run out about 64,000 feet before it will be necessary to join another coil to it. While each strand is being made up, it will rest in a temporary saddle. When the cable is complete, it will be taken from this saddle and dropped into place. Thus, the cables will at first be somewhat higher than their final actual position.

THE ANCHORAGES.

The ends of the cables will pass into great bars called "eyebars"—each having a loop in its outer end. These eyebars are deeply embedded in the masonry, there being twenty bars to each anchorage on either side of the river.

Each eyebar is composed of steel, and the bars are arranged in sets. There will be four eyebars to every three strands.

Actual cable making on the great bridge has begun, and, as has been said, the structure will be completed in about two years. The chief engineer is Mr. L. L. Buck, who worked with Mr. Roebling on the Brooklyn Bridge and also built the famous suspension bridge across Niagara Falls. The bridge will, on completion, be a veritable triumph of twentieth-century engineering.

MILLING MACHINES

BY

JOSEPH HORNER.

This article illustrates boxes of gears for producing positive feeds. It also treats of circular milling, and vertical spindles.

IV.

THE principal recent geared feeds illustrated in this article are of special interest at the present time, because the trend is unmistakably in the direction of the substitution of these for belt feeds. But two years ago they were still retained by the leading manufacturers; now they are no longer in evidence in their practice. One cannot wholly attribute this change to mere fad or fashion, though the belt system is still retained in many good machines. It must be recognised as one result of the present demand for the heavier duty required from milling machines, in common with other tools, such as lathes, grinders, planing machines, gear cutters, etc.

In the milling machine there is one case particularly for which the powerful geared feeds are eminently suitable, namely, the feeding of heavy work vertically. The elevation of a heavy table with a massive piece of work upon it makes severe demands upon the feed, which is better met by toothed wheels than by belting, unless the latter is of good width, and taut.

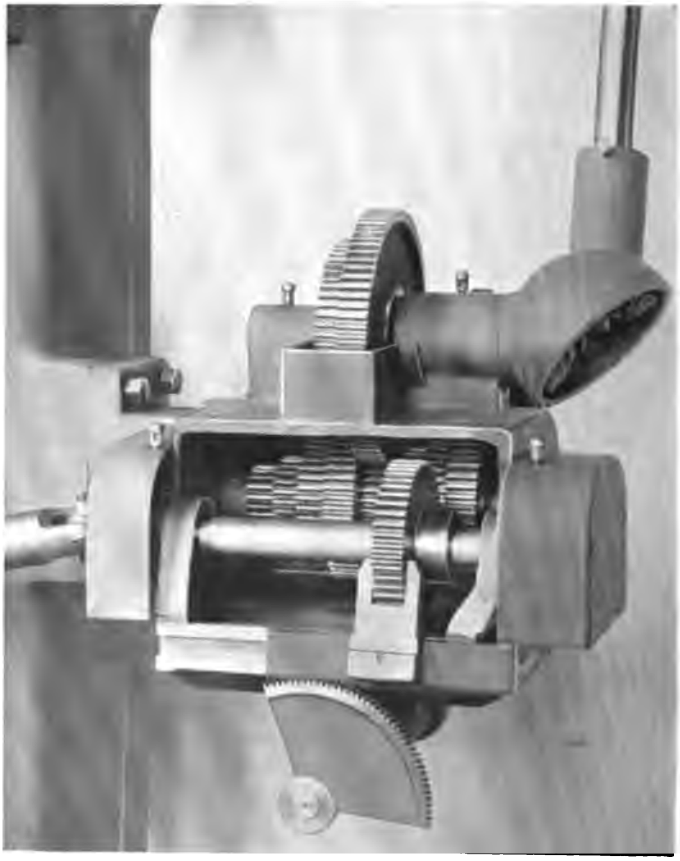


FIG. 4. REAR VIEW OF LOWER GEAR BOX OF CINCINNATI MACHINES, WITH COVER REMOVED.

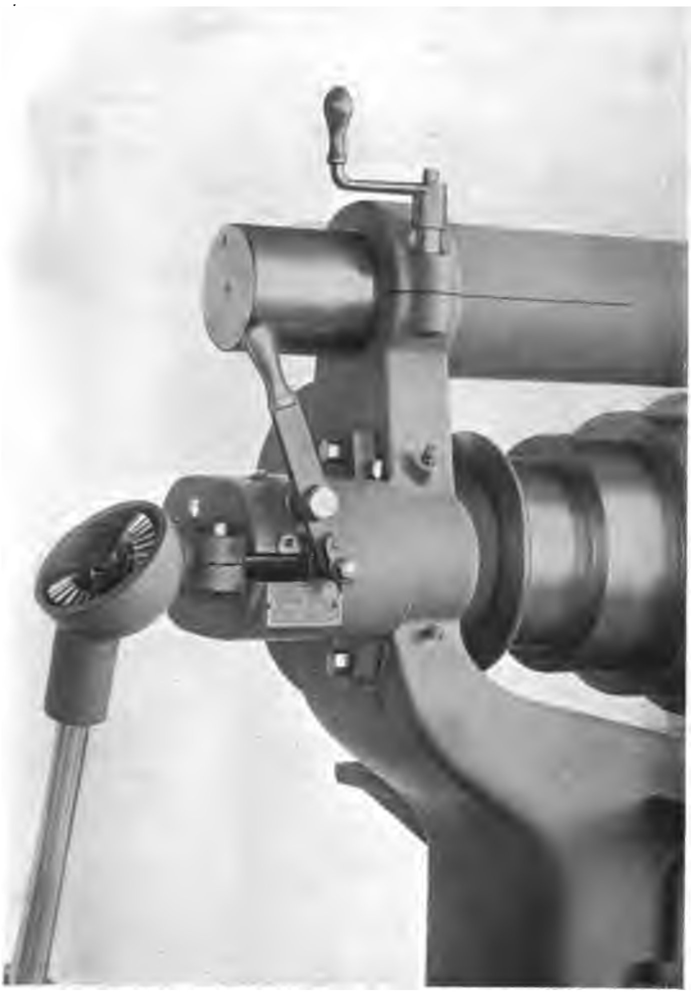


FIG. I. UPPER GEAR BOX OF CINCINNATI MACHINES, WITH COVER REMOVED FROM MITRE GEARS.

THE FEED ARRANGEMENTS OF THE NEW CINCINNATI MACHINES.

The Cincinnati Milling Machine Company now derive the feeds from the spindle, on their back geared machines, in place of the belt cones previously used. The positive feeds can be changed by simple lever movements while the machine is running. From twelve to sixteen changes are thus obtainable on different machines. The illustrations (figs. 1 to 4) will render the method of operation apparent.

The gears are contained in two boxes; one at the rear end of the spindle (fig. 1) shown in section in fig. 2, the other below, at the rear of the column (figs. 3 and 4), the two being connected by a vertical telescopic shaft. In fig. 4 the covers by which the wheels are enclosed in the box are removed to show the internal arrangements. For every spindle speed, two speeds are imparted to this shaft by the sliding gears A, in the upper box (fig. 2), by means of the lever seen in fig. 1. Two feed gears in the lower box are thus driven in the first place. These are the upper ones in fig. 4. Each one is in permanent engagement with a wheel on one of two nests of cone spur gears—the lower wheels in the box (fig. 4) mounted loosely on their shaft, and independent of one another. The larger of the two upper gears engages with the smallest wheel on the right-hand cones, the smaller meshes with the largest wheel on the left-hand cone, so that these run at widely different rates.

The means by which varying rates are transmitted thence to the machine slides are by the intermediate sliding gear in fig. 4—the one which stands out to the front, on

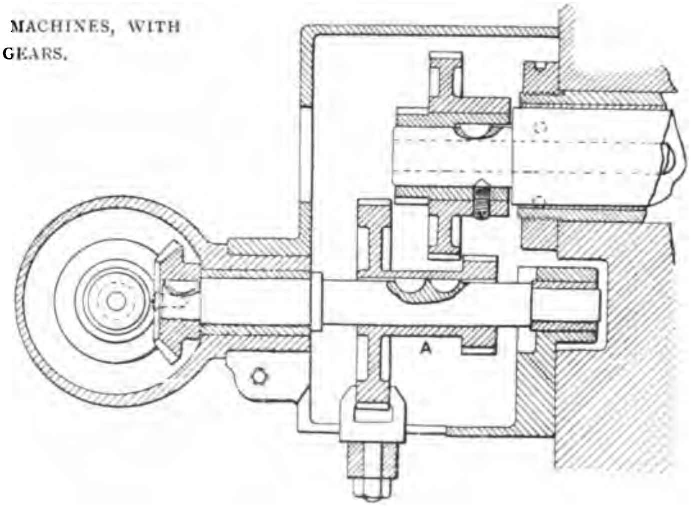


FIG. 2.

its own separate spindle. This is moved along its shaft and brought into engagement with either wheel on the series of cones. It is moved longitudinally by the rack and sector seen below. The lower lever is placed in position opposite figures marked on the quadrant (fig. 3), which indicate the rate of feed in thousandths of an inch per revolution of the spindle. The intermediate wheel is now brought into engagement by the upper lever (fig. 3), which moves the mechanism bodily. A helical groove in the hub of the lever engages a pin in the slide which carries the intermediate gear and the sector rack and lower lever. The gears are of steel, cut, and the bearings of bronze.

The driving cone and back gears are so proportioned that each of the sixteen spindle speeds is correct for the most suitable surface speed for cutters of standard diameters, when working at speeds of 20, 40, and 60 ft. per minute.

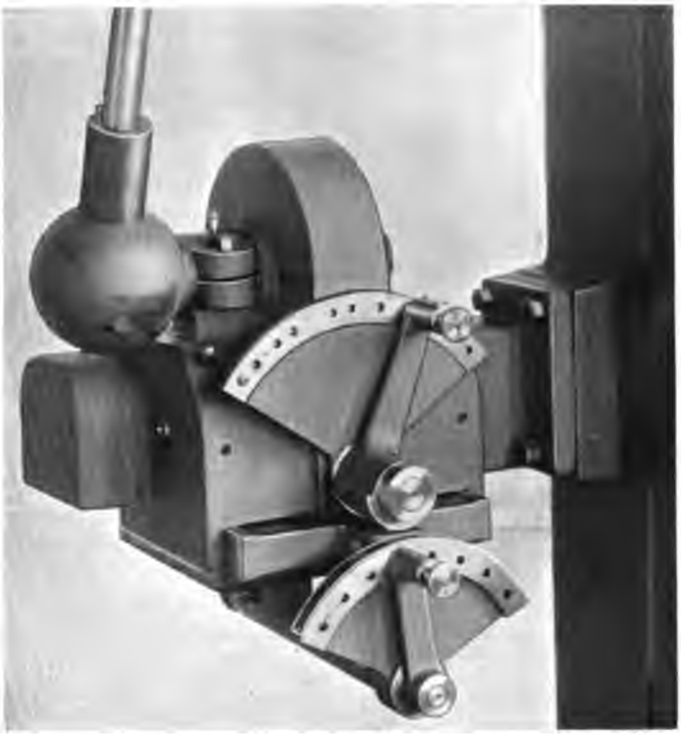


FIG. 3. EXTERNAL VIEW OF LOWER FEED BOX ON NEW CINCINNATI MACHINES.

THE GEAR BOX OF THE NEW BROWN AND SHARPE MACHINES.

The latest Brown and Sharpe feed is also an interesting one. One of the machines to which it is applied was illustrated in fig. 3 in the August issue, and that, with the sectional view (fig. 5) here given, and description, will render its essential features clear. In this case also the feeds are derived from the spindle speeds. Sprocket wheels and a pitch chain are used, driving from the spindle to the change gear box at the side of the pillar, A (fig. 5) being the driven sprocket. This rotates the shaft, B, on which are two wheels, C, D; C running on the shaft with a long boss, and D running on the boss of C. These are actuated by the clutches, *a* and *b*, by the movement of a lever outside the box, the range of movement of the clutch being arrested in each direction by a knob. When gear C is in operation a slow series of feeds is thrown in; with gear D, a series of quick ones. Either movement is transmitted

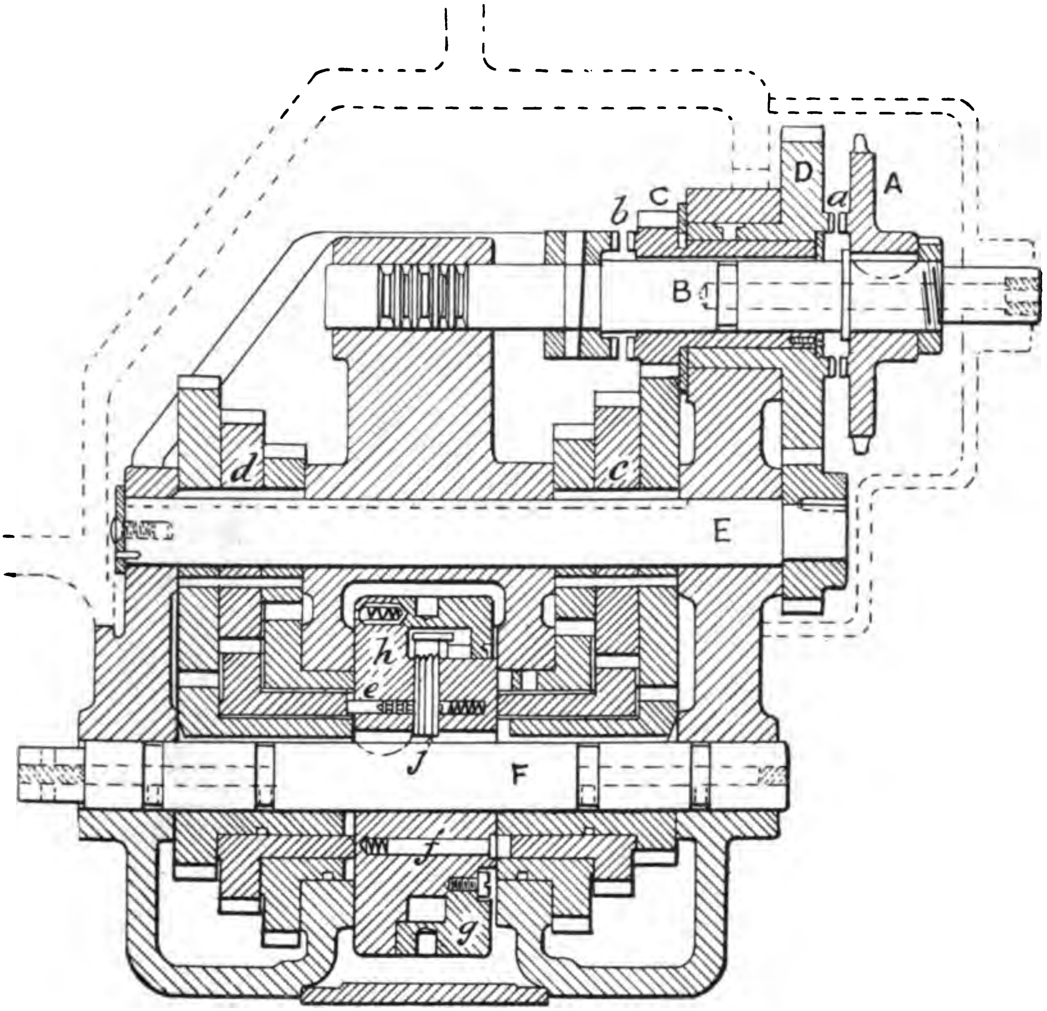


FIG. 5.

through an intermediate shaft, E, to the loose wheels on the feed shaft, E, which transmits power to the table through a telescopic shaft. The two sets of gears, *c* and *d*, are keyed upon E. The loose wheels on F have long hubs running one upon another, except those at the extreme ends, which go directly upon the shaft. These wheels are engaged by a series of six locking pins, two of which are shown at *e* and *f*, and which enter recesses in the hubs of the gears. An index disc, *g*, controls the position of these pins. It turns on the disc, *h*, and carries a cam for actuating levers that are fastened to the ends of small pinions that engage with rack teeth cut in the locking pins—details not shown in this figure. The pinion levers drop into a recess in the index disc, and, as there is but one recess, only one feed can be engaged at one time.

THE GEAR FEEDS OF THE GARVIN MACHINES.

The latest machines by the Garvin Machine Company, for whom Messrs. C. W. Burton, Griffiths and Co., of London, are the English agents, differ in several details from common types. There is no telescopic shaft, but movement is communicated to a vertical feed shaft situated within the column. The feed is chain operated, and derived from a sprocket wheel on the rear end of the spindle. Slack is taken up by moving the feed box bodily vertically, with an adjusting screw.

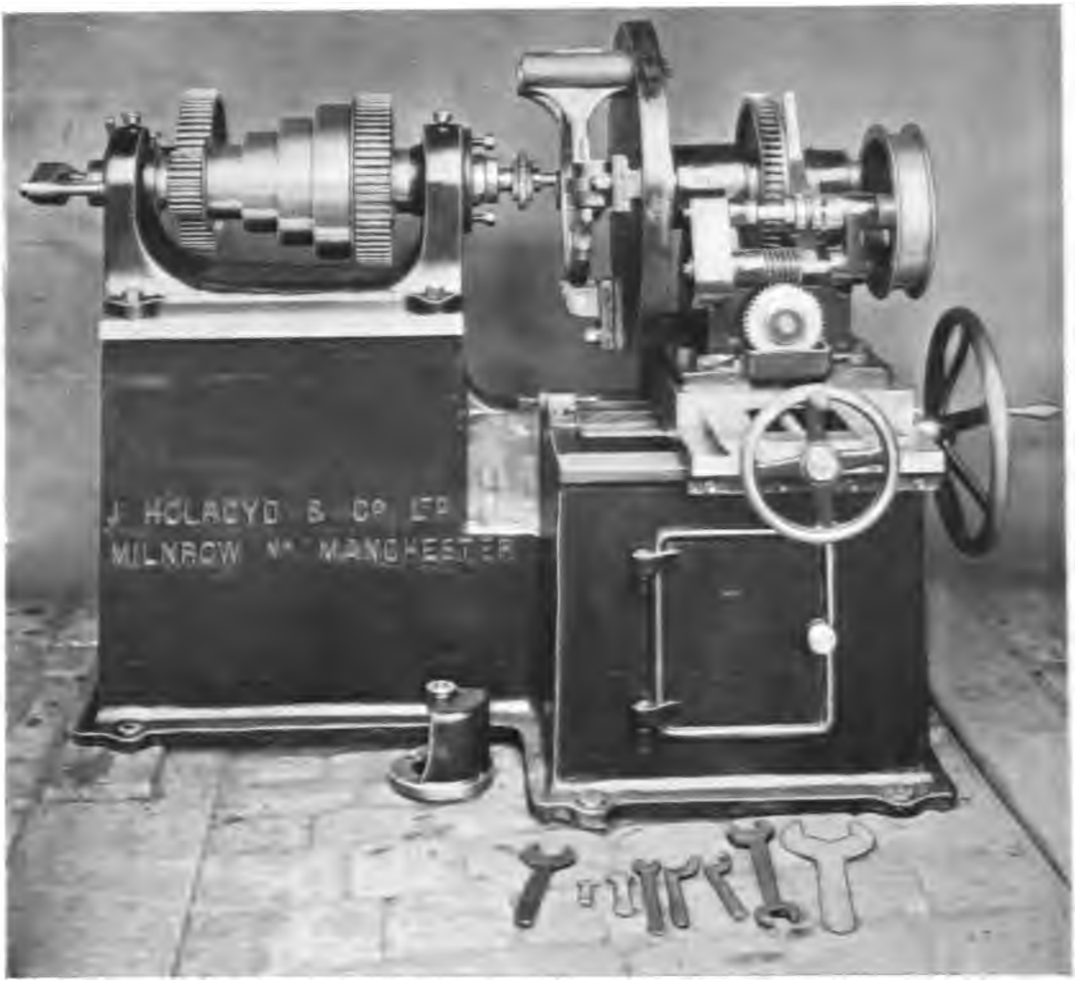


FIG. 6. CIRCULAR MILLING MACHINE.

Nine changes of feed are obtainable directly by cones of gears in the box, and nine more by transposing the wheel and pinion on the spindles at the end of the gear box. The eighteen changes thus obtained range from $\frac{1}{270}$ in. to $\frac{1}{4}$ in. for each revolution of the spindle. The change gears are hardened, and run in oil. They are put into engagement by means of index levers and spring keys, and locked by a lever in notched dial plates.

CIRCULAR MILLING.—THE HOLROYD MACHINE.

Firms specialize around standard types of machines, and in some cases the additions practically constitute a new type. Thus in the machine by Messrs. John Holroyd and Co., Ltd., of Milnrow, near Rochdale (fig. 6), a horizontal miller possesses the apparent anomaly of being without vertical adjustment either to the head or the table. The reason is that an attachment is fitted on the table to perform one function only, namely, that of circular milling. This is a class of work that the lathe is being deprived of by the milling machine, and which has been performed regularly for some years past on worm wheel blanks. Its special value lies in tooling light wheel rims, and rings that would be very liable to spring if done in a lathe. This practice is sufficiently promising to induce Messrs. Holroyd, who make a speciality of milling machine manufacture, to design the tool here illustrated in figs. 6 to 9. The photo (fig. 6)

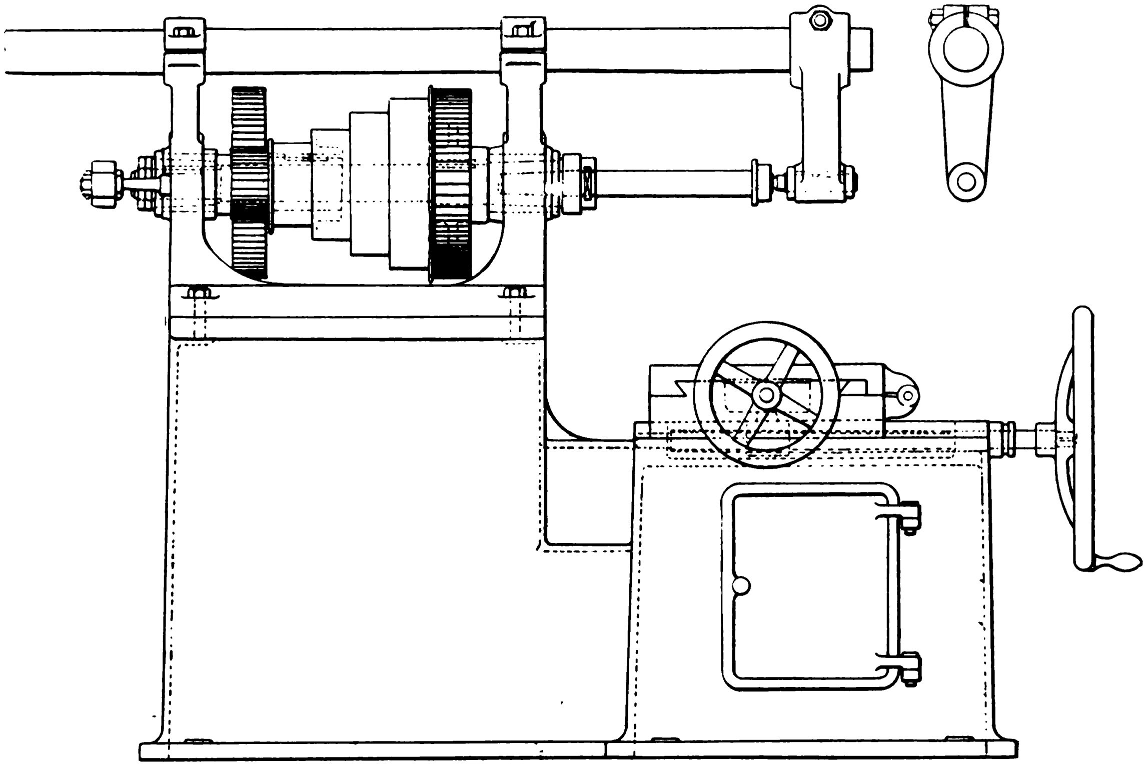


FIG. 7.

shows a strap being tooled internally with a cutter having the sectional form of the recess in the strap. This machine takes work up to 14 in. in diameter. The drawings (figs. 7 to 9) are given to show details which are not apparent in the photo. They illustrate a machine designed for the same class of work as fig. 6, but larger, taking diameters up to 24 in.; besides which there are some little differences in the details. The construction will be understood by the aid of the following remarks:—

The headstock (fig. 7) is bolted on a base, which has an extension in front of the head, coming forwards, ┐ shaped in plan to carry the circular attachment. The headstock is of ordinary back-geared lathe type, having a steel spindle, with conical necks, and provision for taking up wear. The four-stepped cones and back gears give eight changes of speed. The cutter arbor fits with a tapered shank into the spindle nose, and its outer end is supported by a bracket from the arm overhead, which can be removed when it comes in the way, as for internal milling. In the machine illustrated by the photo (fig. 6) there is no overhead arm and no support to the arbor. In this machine, too, the work in the circular milling attachment is rotated from a single stepped pulley with flanges; in the other (figs. 8 and 9) it is driven from a three-stepped pulley, which can be thrown out of action by a lever and sliding clutch.

The driving is through two sets of worm-gear, seen in the photo and drawings (figs. 6 and 8). The first worm, *a*, driving wheel *b*, is operated from the clutched pulley-shaft, A, through a pair of equal spurs, *c c*, encased. It should be noted that *c c* are really change wheels, and an extra pair is supplied which are not equal to each other. In this way the circular feed can be reduced or increased, and nine different rates of feed are obtained from the three-stepped cone pulley. The second worm, *d*, which is divided to take up wear, is on the spindle of the worm-wheel, *b*. A slow, powerful drive is thus obtained to the

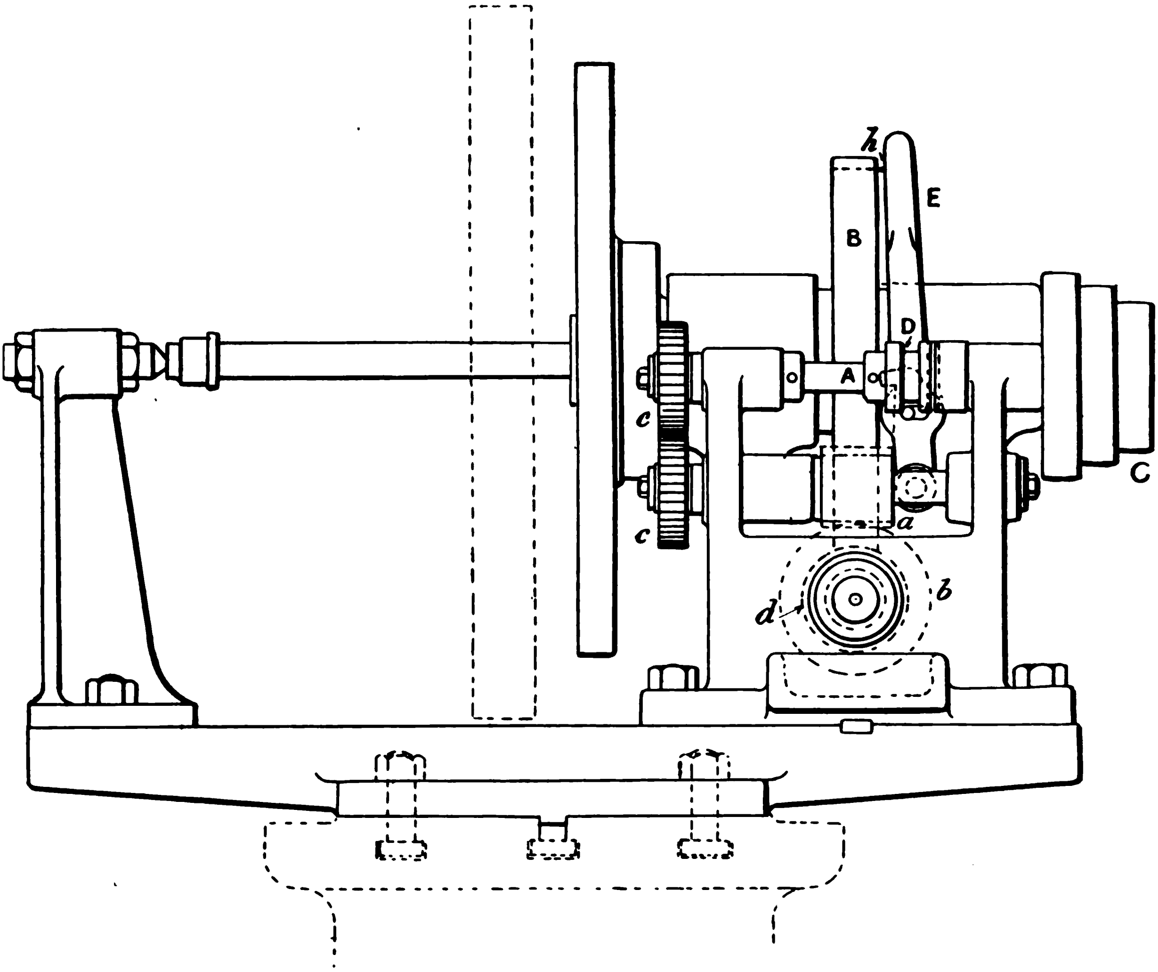


FIG. 8.

wheel, B, which in the case of fig. 8 can be varied by the stepped cone-pulleys, C, on machine and counter. The cross adjustments of the compound slides are effected by hand wheels, but there is an automatic trip and stop motion, which is adjustable round the large worm wheel, B, to arrest the rotation at any point, and which operates by throwing over the clutch, D. The manner in which this is effected is as follows :—

The hand lever, E, has a long boss, and facing this is another boss belonging to a trip lever. A long pin, *f*, connects the two, so that when the latter is moved the hand lever through its slipper block, *g*, throws out the clutch, D. To render the trip automatic at any point, a loose ring, *h*, is fitted against the face of the worm wheel, B. These details are seen in fig. 8, but some of them are enlarged for greater clearness in Fig. 9. The worm wheel, B, has an annular groove, *i*, to receive a couple of locking bolts, by which the ring, *n*, can be secured against the face of the wheel at any position. The object of this is to bring the notch, *k*, in the ring at any desired part of the circle. The notch receives the free end of the trip lever, *e*, which is pushed into the notch on arriving opposite to it by a coiled spring, and so pulls out the clutch, D, by operating the clutch lever, *e*, through the long pin, *f*. The set screw, *l*, can be adjusted to compensate for the wear of the end of the lever in its contact with the face of the ring. The position of the cutter arbor is indicated at F.

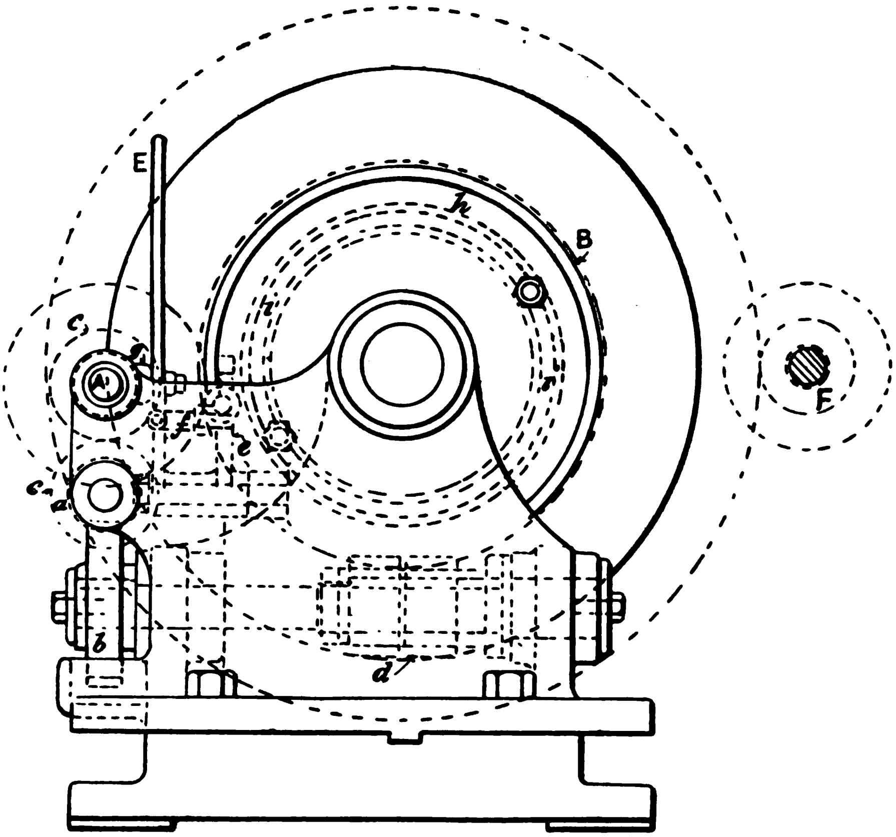


FIG. 8. (SECTION.)

VERTICAL SPINDLE ATTACHMENTS TO HORIZONTAL SPINDLE MACHINES.

Hitherto we have considered the horizontal spindle machines only, and for the greater number of operations which are performed on pillar and knee machines the horizontal arrangement is best. But so many cases arise in which it is either desirable or necessary for the spindle to be set vertically, that a goodly number of machines are made with auxiliary vertical spindles. Several machines, also of the pillar and knee type, have their spindles set permanently in a vertical position instead of horizontally.

One of the principal advantages which the horizontal spindle possesses over the vertical is that both edge and face cutters can be used upon it. The horizontal arbors for edge mills are supported by the overhanging arms, the face mills are carried only by the spindle. In vertical machines, a few of those of large dimensions excepted, no support is given to edge mills beyond that afforded by the spindle, and this limits the depth of work on which they can operate with heavy cuts without risk of chatter.

A vertical spindle attachment is a most useful adjunct for key-seating, and cutting tee slots, worms, and spiral gears, etc., when pieces cannot be placed at right angles with the table. The attachment is supported from the overhanging arm, and the spindle is driven from the main spindle, either by spiral or bevel gears. The spindle is also capable of being set at any angle, from the vertical to the horizontal. A stage further is reached when the attachment is made universal, a design which is added to

Continental machines more than to those of American or English manufacture.

THE NEW CINCINNATI VERTICAL SPINDLE HEAD.

The advantages of being able to use a vertical or horizontal spindle at will is the reason of the popularity of that large number of designs in which both are embodied, together with provision for setting the head at any vertical angle. But if the volume of work will justify the laying down of machines of both types, then it is better to keep them distinct. If not, the next thing is to see that rigidity and accuracy are not sacrificed in order to gain the convenience of two-spindle machines. An illustration of what a combination head of this kind should be, is seen in a new one by the Cincinnati Milling Machine Company (fig. 11), and in the sectional elevation (fig. 10). The head can be swivelled in a vertical plane through 360 deg., by means of a circular tee groove, A. The circle bearing the graduations is divided into degrees, and is large, being 8⅝ in. in diameter, which is an important feature, because it brings the graduations sufficiently far apart to read clearly. Four ⅝-in. bolts secure the head in place. The body swivels in a bracket, B, that is clamped on the overhead arm, C, which steadies the overhanging portion that carries the vertical spindle. When there is occasion to change cutters, while the work is on the machine, the head can be swung at an angle, and the operator has all the room he

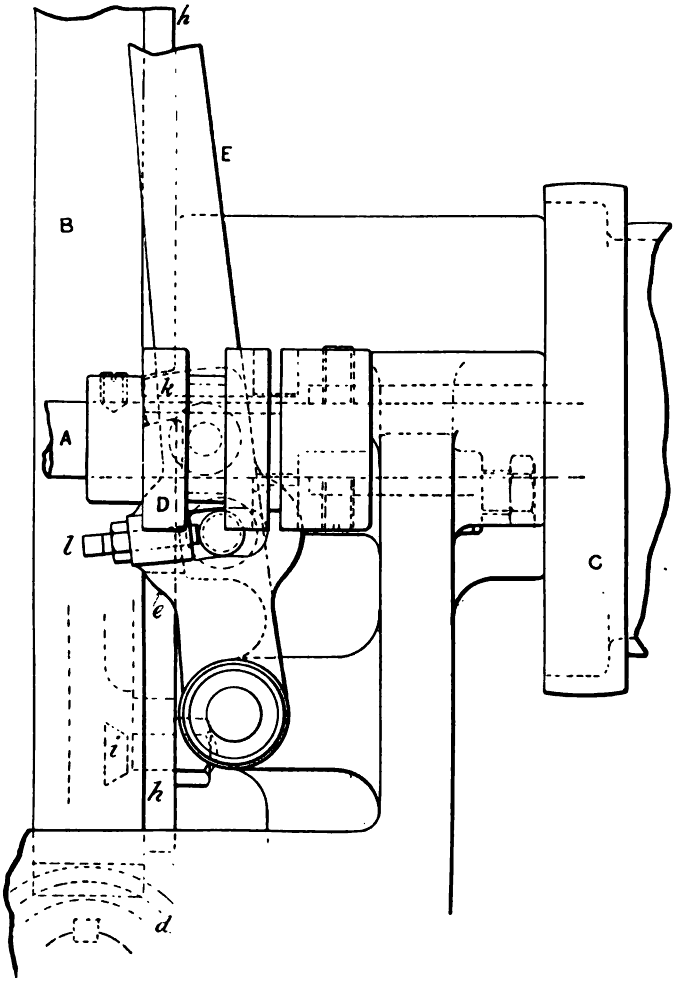


FIG. 9.

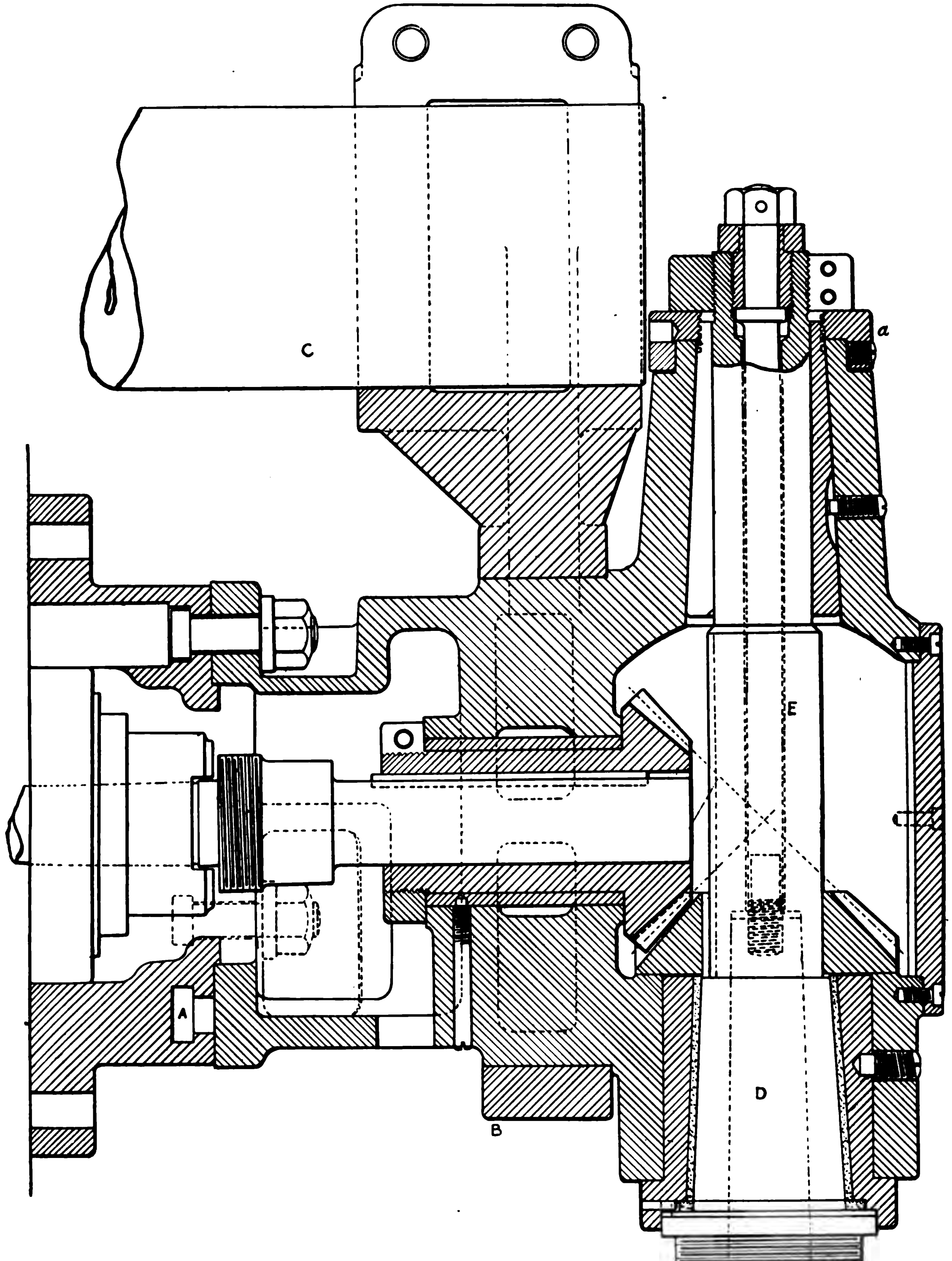


FIG. 10.

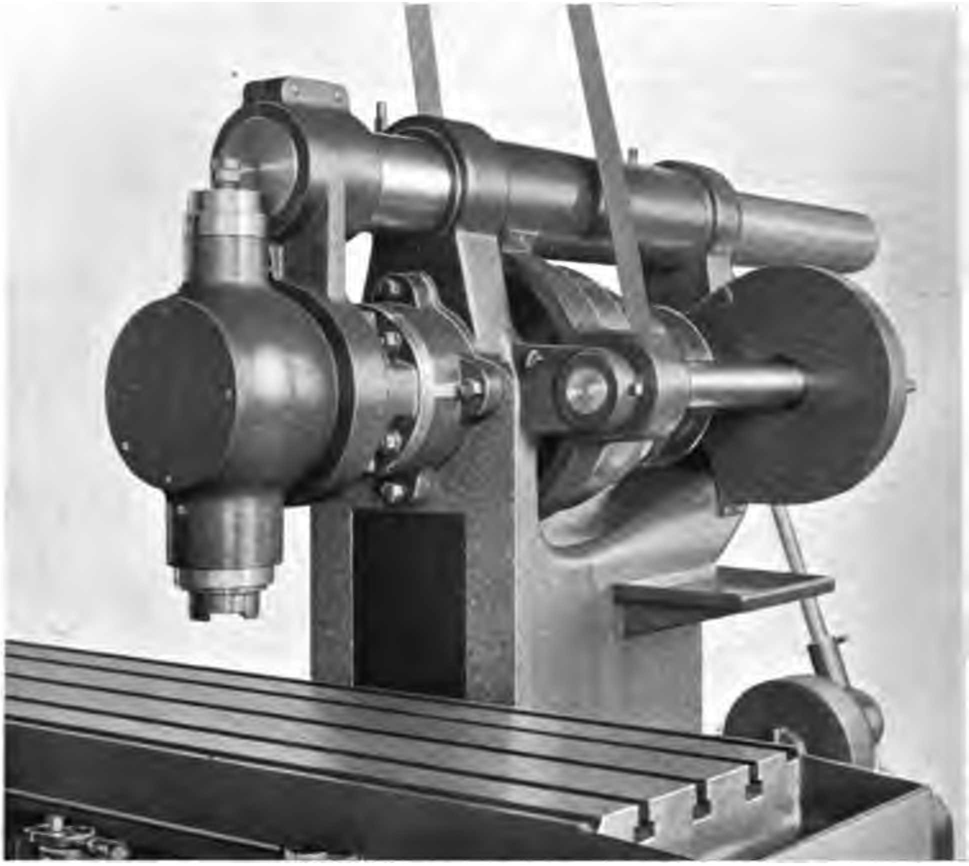
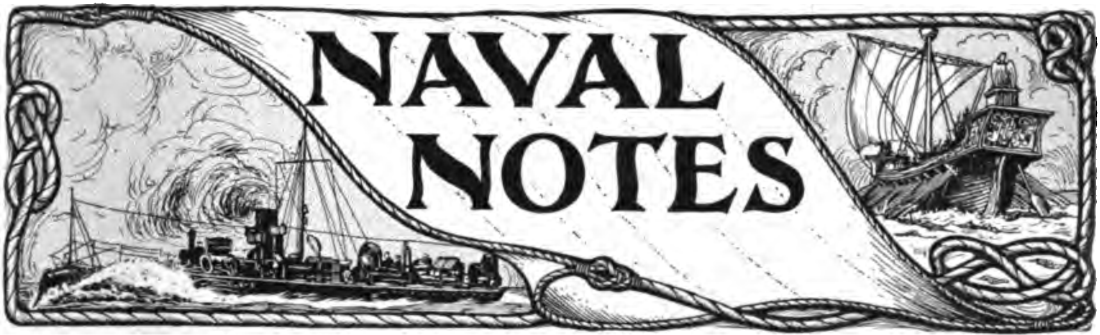


FIG. 11. VERTICAL SPINDLE ATTACHMENT BY THE CINCINNATI MILLING MACHINE CO.

requires for making the change. This obviates the awkward position which often arises from a lack of room for changing cutters on the usual rigid vertical spindle miller.

The spindle, D, is tapered at its lower end, and runs in a babbitted bearing. It is adjusted to this bearing by means of the lock nut on its upper end. The upper box is of bronze, and tapered on its outside. It is adjusted to this end of the spindle by means of the lock nut, *a*, on the box. This method of adjustment is similar to that used on the horizontal spindle of the machine. Particular notice should be taken of the method of securing the cutter shanks in the spindle. These shanks are shaped in the form of a clutch, which matches another on the spindle. This takes the place of the usual tang on the end of shanks. In this case the ends of the shanks are tapped $\frac{5}{8}$ in. to fit the bolt shown at E, and by which they are firmly secured. The bolt is provided with a shoulder near its head so that it can be used for backing a shank out as well as for drawing it in. The end of the spindle is threaded on the outside the same as the end of the horizontal spindle of the machine, and both spindles have the same size taper hole, so that all tools are interchangeable between the two spindles. With this attachment the horizontal spindle miller is readily converted into a vertical spindle machine, capable of doing heavy work, thus embodying in one machine the advantages of both. It will work a 6-in. diameter face mill in cast iron.



NAVAL NOTES

MONTHLY NOTES ON NAVAL PROGRESS IN CONSTRUCTION AND ARMAMENT.

BY

N. I. D.

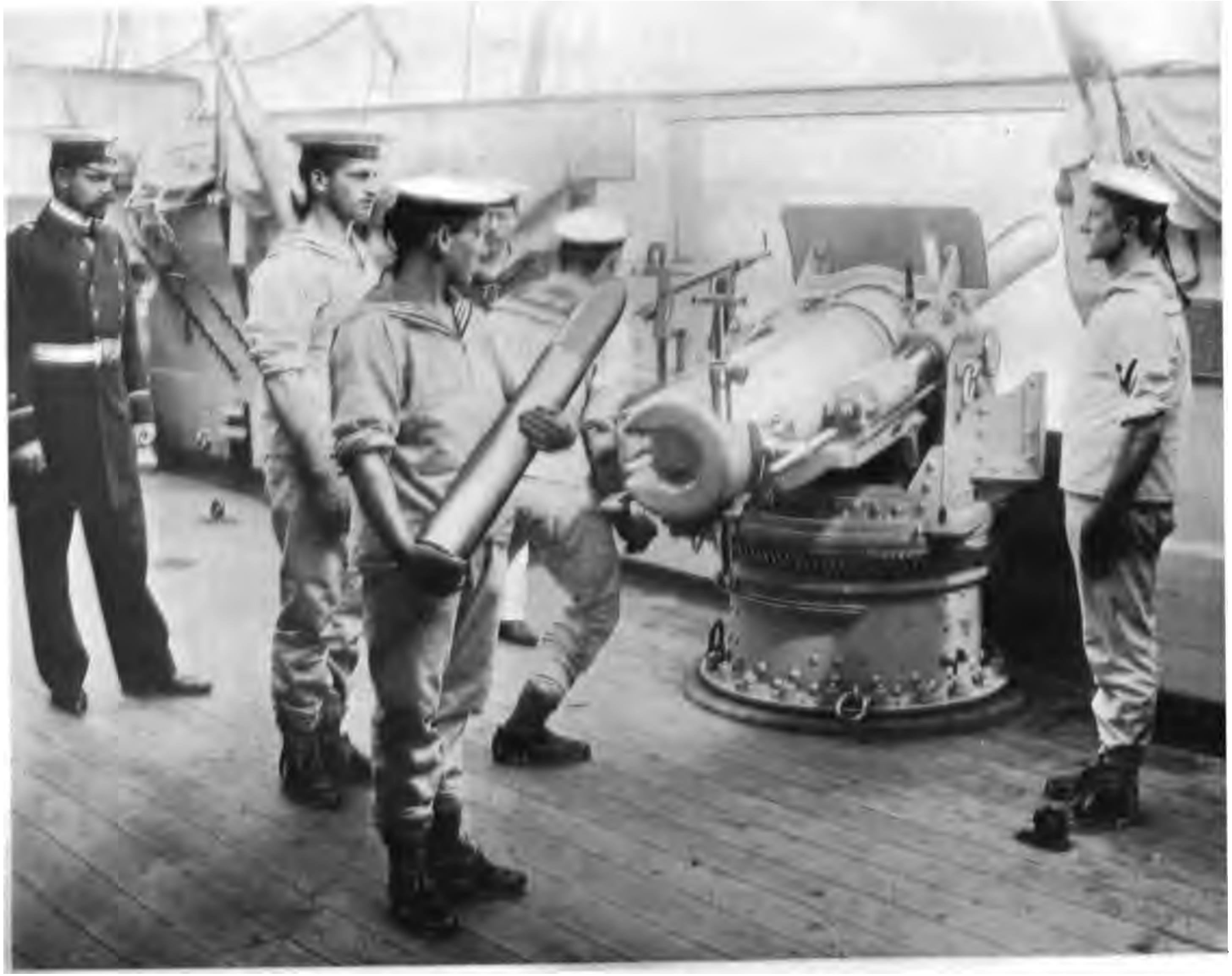
A SURVEY of recent works in the British dockyards does not reveal any great acceleration of pace in construction. The *Suffolk* is still slowly making headway at Portsmouth, where the *Kent* was greatly delayed, and within two years and a-half only two armoured cruisers have been laid down. There appears to have been a great deal of wasted labour, and it would seem that a sounder system was required. A better state of things may follow the appointment of the new Admiral Superintendent, and the building slips should soon be provided with other work. The *Queen* and *King Edward VII.* are going on steadily, but in a rather leisurely fashion at Devonport. Much progress has been made at Chatham, and it is hoped that, with the completion of the new jetty at Pembroke, work will be conducted more rapidly and economically at the latter port. There appears to be no doubt that the new light thrown upon the value of the "Johnson cap" is leading to some revision of plans, and that construction may be somewhat retarded in consequence.

The past month has been a quiet one. The battleship *Venerable* has been under trial, and is to be commissioned for the Mediterranean this month. The *Montagu* has also been undergoing steam trials, and in the four-fifths power trial attained a speed of 17·8 knots as the mean of four hours, with coal consumption of 1·78 lbs. per i.h.p. per hour. She was in an advanced state, and the guns for the secondary batteries had been taken in from the Naval Ordnance Depôt. The armour belt of Krupp steel in the class extends for 290 ft. of the length, with a thickness varying from 3 in. at the bow to 7 in. amidships. The barbettes are protected by 11-in. plates, while the casemates are of 6-in. armour. The thickest armour, 12 in., is that which protects the conning tower. Reference was made in the August number to those ships of this class which had already completed their trials. The *Montagu* has been promised by the officials at Devonport Dockyard approximately for March of next year. She is to pass through a special series of trials additional to the ordinary steam trials, to test her steering capabilities under various conditions of helm at particular speeds, including engine-reversing experiments.

The battleship *Queen* will be completed in March, 1904, and the *King Edward VII.* a year later. The latter vessel, it is estimated, will have cost £1,500,000 by the time she is completed.

Of the armoured cruisers, the *Hogue* is now completed, and will be a valuable addition to the Mediterranean Fleet. The *Bedford* failed to realise the estimated speed on her steam trials, and will be fitted with propellers having a larger blade area, a change calculated to increase the speed by at least half a knot. It is currently reported that other ships of the same class which are under construction have had a similar change made.

The armoured cruiser *King Alfred*, built, engined, and armed by Messrs. Vickers, Sons and Maxim, Ltd., has concluded her thirty and



GUN DRILL ON BOARD A GERMAN BATTLESHIP. KRUPP QUICK-FIRER.

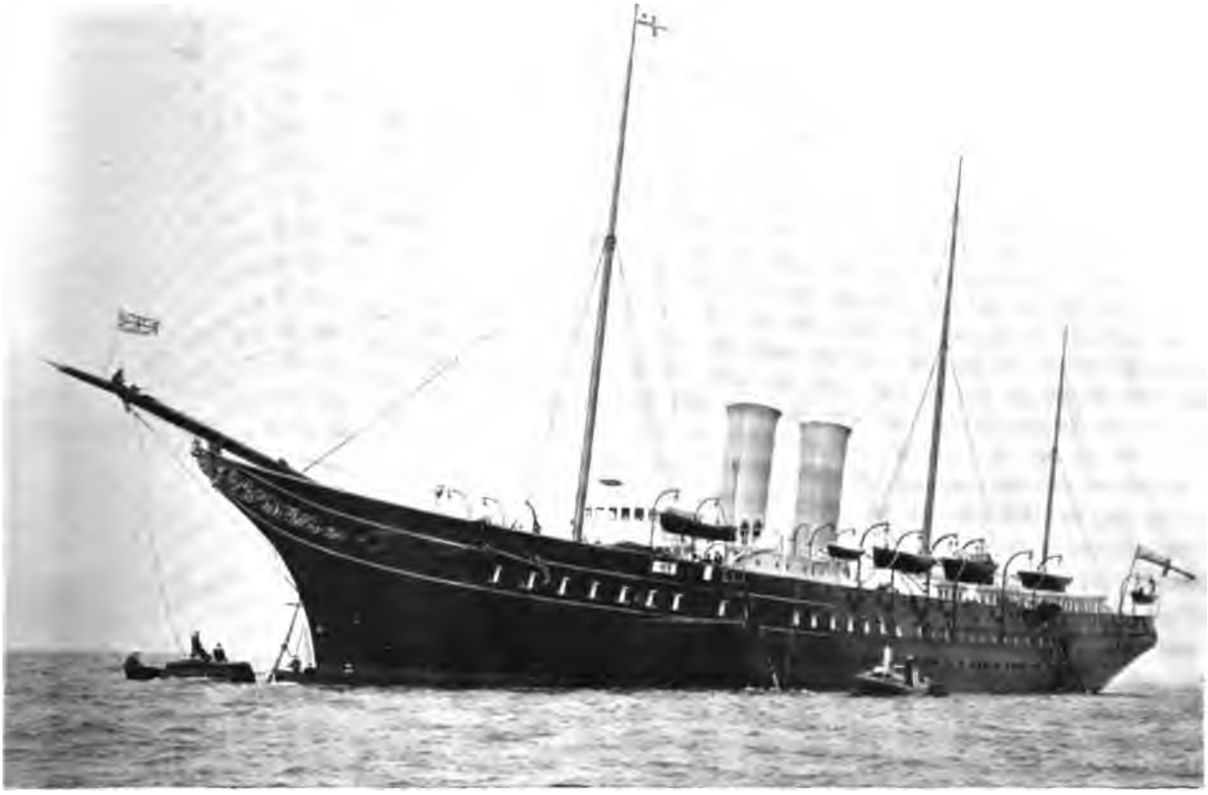


Photo by Wm. V. Kirk and Sons, Cowes, I. W.

THE ROYAL YACHT "VICTORIA AND ALBERT."

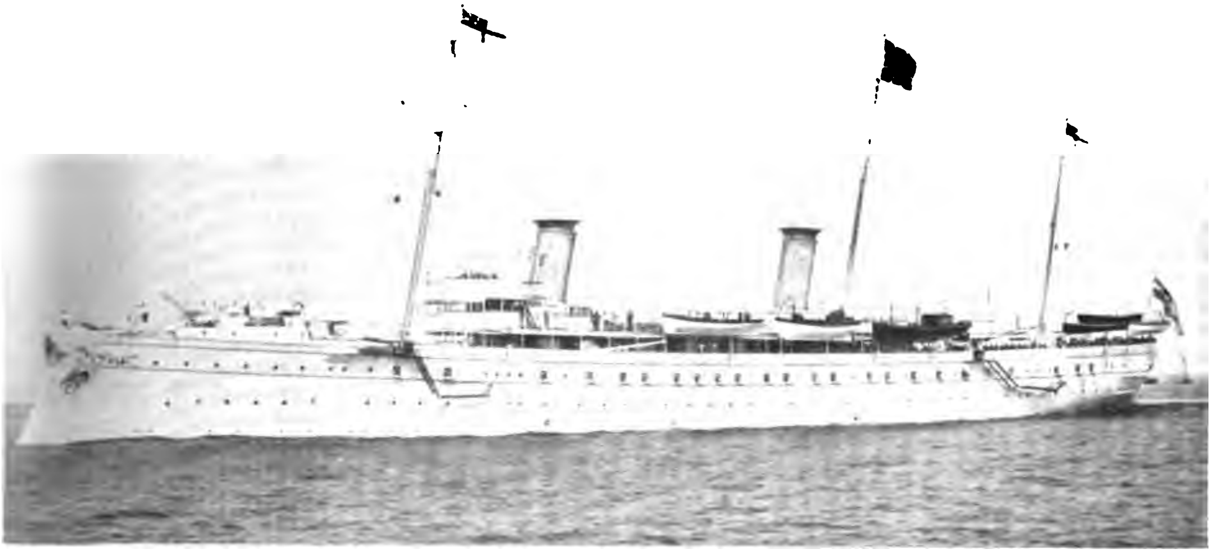
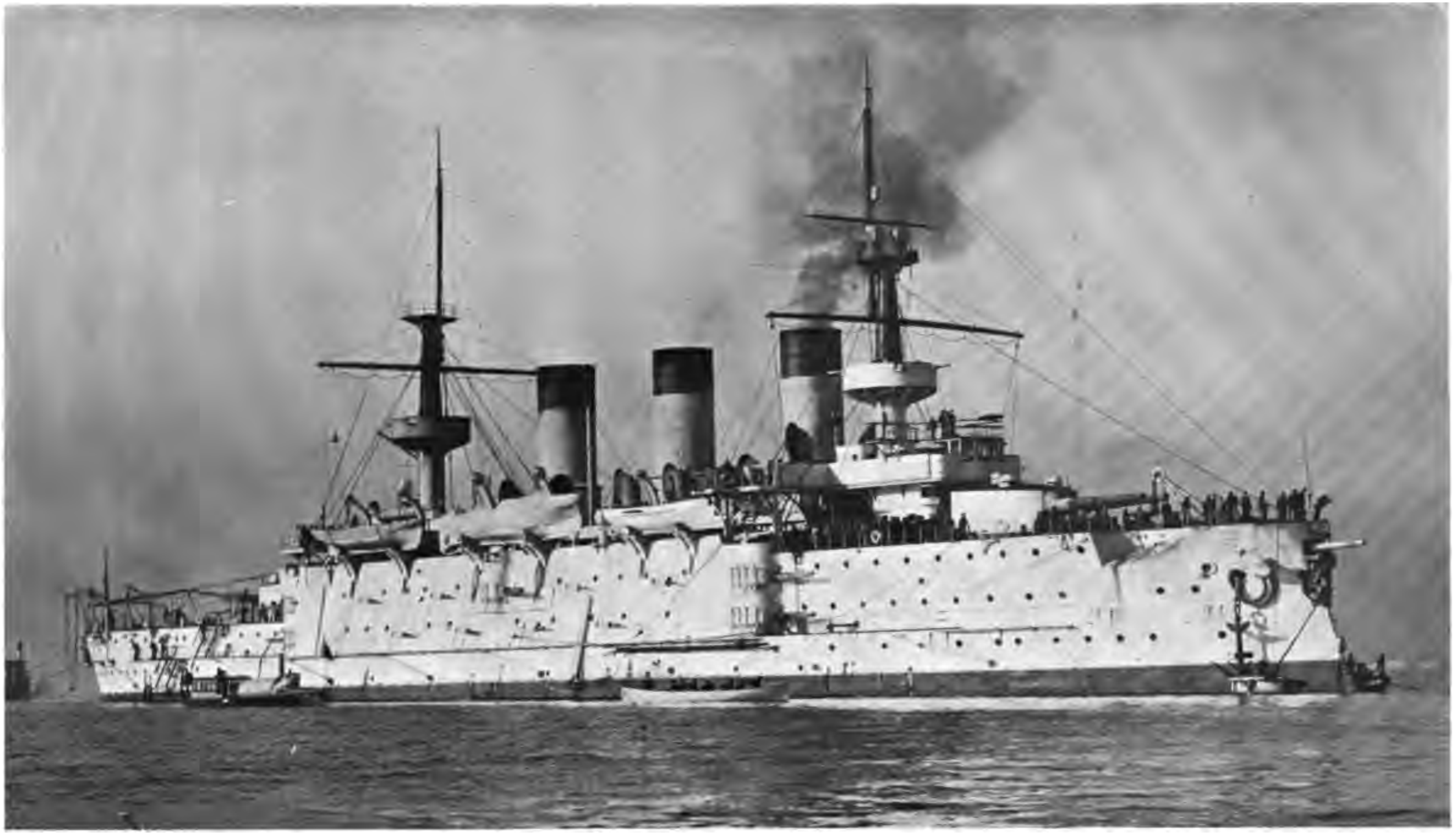


Photo by Wm. V. Kirk and Sons, Cowes, I. W.

THE GERMAN EMPEROR'S YACHT "HOHENZOLLERN."



From the Journal of the Royal United Service Institution.

THE NEW RUSSIAN FIRST-CLASS BATTLESHIP "PERESVIET."

12,674 Tons; 14,500 I.H.P.; Speed, 19 Knots.

ARMOUR PROTECTION.—Waterline belt, 9·5-in. steel; Turret armour, 9-in.; Armoured deck, 2·8-in.

ARMAMENT.—Four 10-in., eleven 6-in. Q.F., sixteen 3-in. Q.F., ten 1·8-in. Q.F., and seventeen 1·4-in. Q.F. guns, with six torpedo tubes eight hours' steam trials. Her mean draught is 26 ft., but on her trials she was below her stipulated load. The revolutions on the one-fifth power trial were 70 starboard and 70·5 port, with a vacuum of 27·2 starboard and 26·4 port. The collective i.h.p. was 6,395, and the coal consumption 1·76 lbs. per unit of power per hour. The speed realised was 15·167 knots. On the four-fifths power trial the revolutions were 106·6 starboard and 106·8 port, with a starboard vacuum of 26·4 and a port of 26 in. The i.h.p. was 11,316 starboard and 11,289 port, giving a collective of 22,605. The coal consumption was 1·82 lbs. per unit of power per hour, and the speed realised was 21·597 knots. On her full power trials the *King Alfred* proved herself the fastest ship in the British Navy, excluding, of course, torpedo craft. Her mean speed on several runs over the Cheshil Beach course was 23·465 knots, as compared with the 23·23 knots of the *Leviathan*, her sister ship. The coal consumption was also remarkable, for, having established the fact that she could steam from Portsmouth to Melbourne at 15 knots without recoaling, the *King Alfred's* consumption on her full power trial worked out at 1·81 lbs. per unit of power per hour, or 0·13 lbs. less than that of the *Leviathan.* The starboard engine running at 118 revolutions developed 15,170 h.p. with a vacuum of 26·6 in., and the port engine with 119·6 revolutions and 15,723 h.p. had a vacuum of 25·5 in. The water expended during the trial was only 39 tons.

There have been doubts as to the stability of the *Essex* class. Successive orders have been received at Pembroke to reduce the top weights, and the funnels have been cut down. Another vessel of the improved "County" class is expected to be put in hand at the same yard; but it is believed that new views in regard to the defensive power of armour, due to the recent trials of the "Johnson" cap, have caused the plans to be delayed. The *Devonshire*, of this class, was laid down at Chatham on March 25th, and now two others have been ordered—the *Hampshire*, of Messrs. Armstrong, Whitworth and Co., at Elswick, and the *Roxburgh*, of the London and Glasgow Company. The *Antrim*, *Argyle*, and *Carnarvon* will complete the six vessels of the class to be laid down according to the programme of 1901-2. Two others are projected for 1902-3.

The *Niger*, torpedo-gunboat, has made satisfactorily progressive trials preparatory to acceptance of her new Reed water-tube boilers from the Palmer Shipbuilding Company. On the three hours' trial, with 6,282 i.h.p., the speed was 20·5 knots. On the five mile trial the highest mean speed with and against tide was 20·7 knots. The whole of the speed trials were perfectly satisfactory, and were followed by successful circle-turning trials.

Several destroyers have been ordered: *Eden* (Parsons' Turbine Company), *Derwent* (Messrs. Hawthorn, Leslie and Co.), *Ettrick*, *Exe*, *Foyle*, and *Itchen* (Messrs. Palmer and Co.), *Ribble*, *Teviot*, and *Usk* (Messrs. Yarrow).

FRANCE.

The battleship *République* has been launched at Brest, and is a sister of the *Patrie*, which is in hand at La Seyne. She is the largest vessel ever built in a French yard, and is the first to take the water of the five battleships included in the programme of M. de Lanessan, late Minister of Marine, the progress of which, however, appears to be greatly jeopardised owing to the new policy which his successor is endeavouring to inaugurate. The displacement of the *République* is 14,865 tons, and she is 434 ft. 10 in. long, with 79 ft. 7 in. beam. The protection is assured by a water-line belt of Harvey steel, having a maximum thickness of nearly 12 in., while the bows of the ship are to be completely enveloped by 3-in. steel. The armoured deck is 2 in. thick on the flat and nearly 3 in. on the slopes, which reach down below the water level. There is also a splinter-proof deck of thin steel placed horizontally. The armament will comprise four 12-in. guns, coupled in turrets plated with 12 in. of steel, eighteen 6·4-in., of which twelve will be in lateral turrets protected by 6½-in. steel, twenty-six 1·8-in. guns, two smaller, and five torpedo tubes. The speed is intended to be 18 knots without forced draught, and the range will be 4,000 miles at 10 knots, with normal coal supply. The ship has been designed by M. Bertin, who proposed to give the maximum of protection possible, and to place below the armoured deck

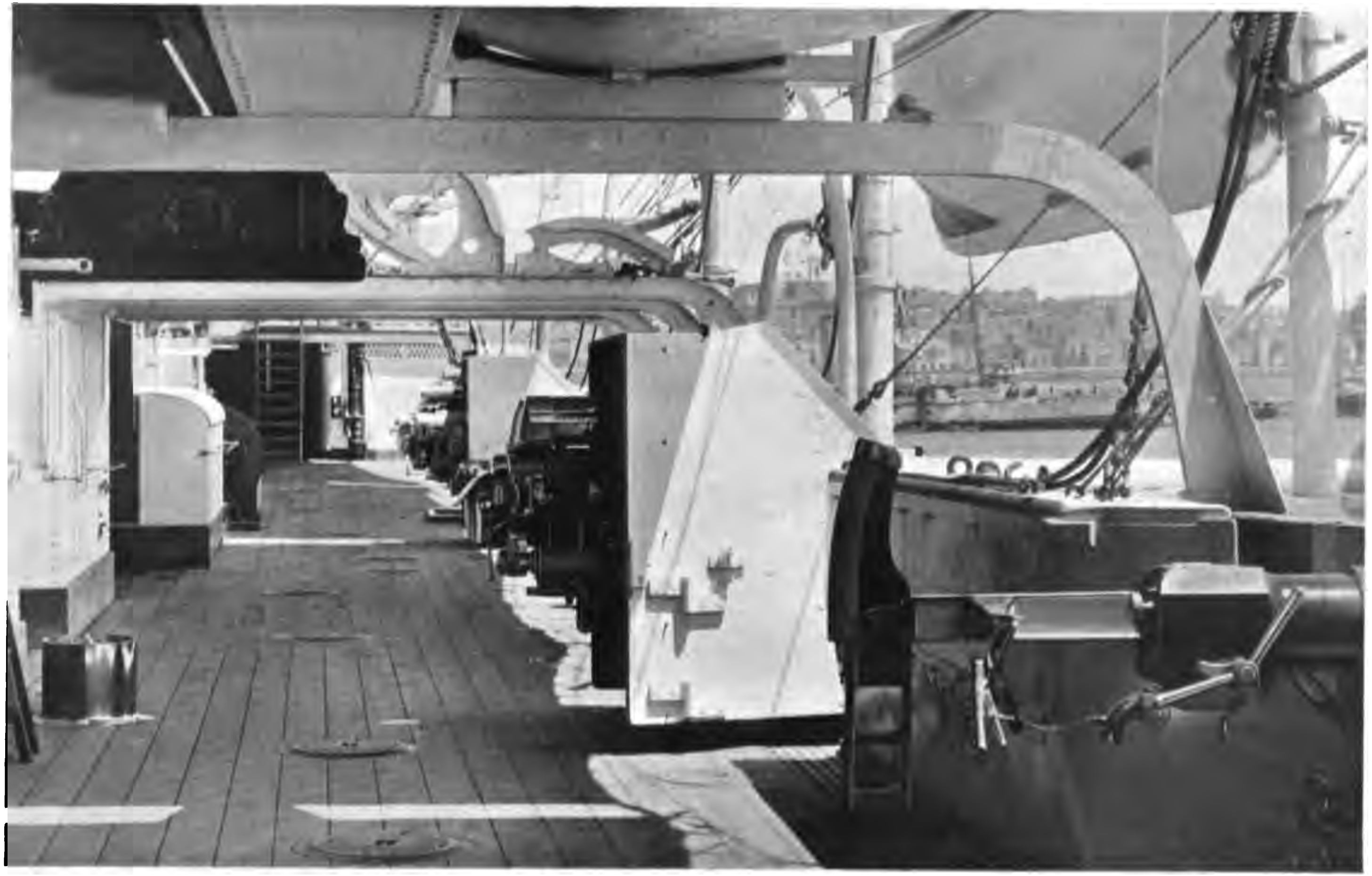


Photo by R. Ellis, Malta.

DECK OF THE SECOND-CLASS CRUISER "CAMBRIAN," LOOKING FORWARD.

and behind the side armour all the vital parts of the vessel. The turret system for the secondary guns, long since adopted by the French, and carried out to a large extent in the new vessels, has now been introduced in British ships of the *King Edward VII.* class.

In a recent return published by the British Admiralty of the navies of the seven great naval Powers, some interesting facts were given concerning the French Navy. Our neighbours have followed our example in putting old vessels on the effective list with the new, but with a difference. Whereas on the Admiralty books vessels armed with muzzle-loaders are still looked upon as effective for coast defence, not one French vessel has a muzzle-loader on board. Built and building, France has 35 battleships, or half as many as Great Britain, and she possesses 45 cruisers already built, and has 17 building, as compared with our 130 completed and 30 or more building. There are also 279 torpedo boats, 31 destroyers, and 15 gunboats built and building on the French list, as compared with 100, 113, and 35 of each class respectively for England.

The armoured cruiser *Jules Ferry* (12,416 tons) is expected to be launched at Cherbourg about March, 1903. Her contract i.h.p. is 27,500, expected to give her a speed of 22 knots. Her engines, which are being made at Indret, will consist of three sets of triple-expansions, with water-tube boilers. The *Desaix*, which has been built by contract at St. Nazaire, will complete her trials at Cherbourg instead of at Brest, owing to the immense pressure of work at the latter port.

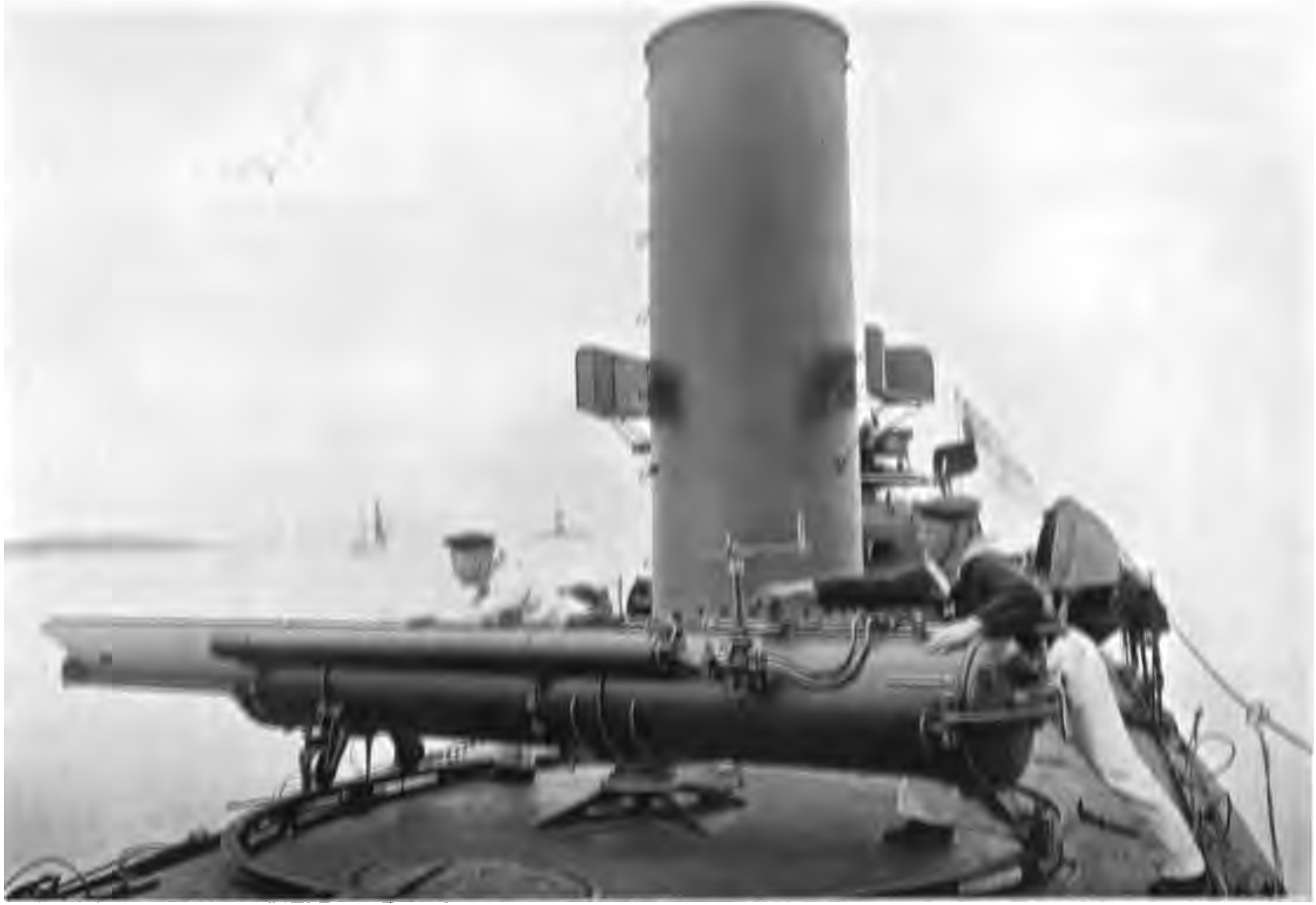
The battleship *Suffren* has just satisfactorily accomplished her full power trials. There is in her an absence of heavy superstructures which have been so marked in some of her predecessors, and she shows many signs of a tendency on the part of her designer to base his plans on the lines of Sir William White's vessels. She has two main and six secondary turrets. She carries sufficient coal for 7,000 miles at 10 knots, and the speed is 18 knots. She is fitted with Niclausse boilers.

The armoured cruiser *Marseillaise* is rapidly approaching completion at Brest. She was only launched two years ago, so that work on her has been fairly rapid. She has all her guns on board, namely, two 7·6-in. breech loaders mounted singly in turrets, and eight 6·4-in. quick-firers, two of which are mounted in casemates with recessed ports on the lower deck aft, two on the main deck forward, and four on the upper deck, in separate turrets. Besides these she has 34 smaller quick-firers and five torpedo tubes, two submerged and three unarmoured above water. She has received her final painting externally, and is of a dull black along the water line and grey for the upper works.

GERMANY.

It is announced that the battleship *J*, which Schichau has in hand at Danzig, being the first of the new type displacing 13,200 tons, will probably be launched before the close of the year, most likely in December. The sister ship, *H*, is expected to take the water at Krupp's Germania Yard, Kiel, next February. The chief advantage in these new ships is that their principal armament will consist of four 11-in. guns, which are somewhat loosely described as "quick-firers." They are the heaviest armament, as compared with 12-in. guns in other navies, and it is claimed for them that they will fire from one to two rounds per minute, whereas the like guns in the *Brandenburg* class can only fire one round in two and a-half minutes. In relation to this claim, it is worth while to note that during the recent prize firing of the *Implacable* in the Mediterranean, in two runs, each of six minutes' duration, thirteen rounds were fired from the 12-in. guns, and that the huge projectiles reached the target eleven times. This aimed firing is a very different matter from a mere record of rapidity in a number of rounds.

The German Government is adhering consistently to the programme laid down in 1900. By that programme 38 battleships were to be built by the year 1916, and 31 of these are now ready or in hand, and it is confidently expected that next year's Budget will include instalments for six others. The twelfth of the 14 large cruisers planned has been laid down this year, and the first instalments for the other two will be asked for in 1903. Progress has not been so rapid with the 38 small cruisers, five only of which



TORPEDO TUBE AND TURN TABLE ON BOARD FIRST CLASS TORPEDO BOAT.

are now in hand or ready; but six more are to be laid down next year.

The coast defence armourclads of the *Siegfried* class are being improved successively by being cut in two and lengthened to increase coal capacity and ammunition stores, and the Admiralty propose to devote £750,000 for this purpose. Of this sum £525,000 has already been voted, and the remainder will be in next year's Budget. The name-ship of the class dates from 1889, and the most recent was completed in 1895. The *Aegir* has a complete electric installation for her guns and ammunition, and of the others the *Hagen* has already been lengthened by 25 ft. The four battleships of the *Brandenburg* class are also to undergo changes, £62,500 having already been granted, and the balance of £87,500 will be asked for next year.

Torpedo boat *No. 108*, of 350 tons displacement, has completed her steam trials at Kiel, and has attained a speed of 29·6 knots. The engines gave every satisfaction, and there was little or no vibration. A division of six destroyers is to be constructed by Schichau at Elbing. They will displace 350 tons, be provided with engines of 6,000 h.p., and are to steam at 28 knots. They will be numbered from S114 to S119.

RUSSIA.

The Baltic Yard at St. Petersburg is engaged on a new fast cruiser, apparently for use as a "scout despatch-boat" for the Pacific Squadron. It is believed that the Governor of Kwang-Tung may use this vessel for his sea voyages. Similar vessels will be built for the other Russian Squadrons as soon as this one is completed, which will be before 1904. She will be of 3,000 tons displacement, and her engines of 18,000 h.p. are to be able to develop 25 knots speed. She will be lightly armed with quick-firing guns and torpedo tubes.

The protected cruiser *Askold* has been undergoing a series of progressive trials, which have given the following results: with 55 revolutions the speed was 10·87 knots; with 70 revolutions, 13·70 knots; with 85, 16·35 knots; with 100, 18·85 knots; and with 115 revolutions she attained 20·11 knots.

The *Bogatyr*, building at Stettin, has also undergone steam trials, attaining a maximum speed of 23·45 knots with 20,000 h.p. The *Askold*, laid down in 1899, has a length of 426 ft. 6 in. and a displacement of 6,500 tons. Her trial speed is half a knot better than was estimated. The protection is slight, the thickest armour, 4 in., being that round the casemates, in which 6-in. guns are mounted. There are twelve of these guns altogether, eight behind shields and four in casemates, besides twenty-two small guns and two submerged torpedo tubes. The *Bogatyr* is very similar, her displacement being about 100 tons less. Her speed also shows nearly half a knot improvement, but the arrangement of the armament is somewhat different. Her 6-in. guns are twelve in number, and four are mounted in pairs in turrets forward and abaft, four in casemates, and four in shields on the upper deck. She has twenty-four smaller guns and four torpedo tubes, two submerged on the broadside.

The Nevski Yard at St. Petersburg is about to put in hand two protected cruisers of 6,000 tons and 23 knots, and many torpedo-boat destroyers will also be shortly added to those already in hand there. They are improved *Sokols*, and it is said will displace 420 tons. The *Boiki* and the *Bravi* (350 tons) have lately attained a speed of a little over 26 knots. At the same yard the *Revy*, *Relivy*, *Ryany*, *Prosorlivy*, and *Bezuprechni* have been launched. Several destroyers have also been put in hand at Nikolaieff. Experiments have been made with the submarine boat of Lieutenant Kolbasieff at St. Petersburg, and later Sebastopol. No details have been permitted to leak out as to the results. It is confidently stated that several submarines have been put in hand in the Black Sea during the last two years, but extreme secrecy is maintained in regard to them, and no details are known.

Work on various new vessels at Sebastopol and Nikolaieff is being pushed on with what is described as a feverish haste. They include a battleship and a 6,000-ton cruiser.

Lieutenant Zhandr has discovered a new composition for painting the underwater portions of vessels, which has been tried on the ships of the Black Sea Squadron, on the recommendation of Admiral Tyrtoff, Minister of Marine, who is stated to have found great advantages in the use of the composition. Hitherto anti-fouling material has been mostly purchased in this country.

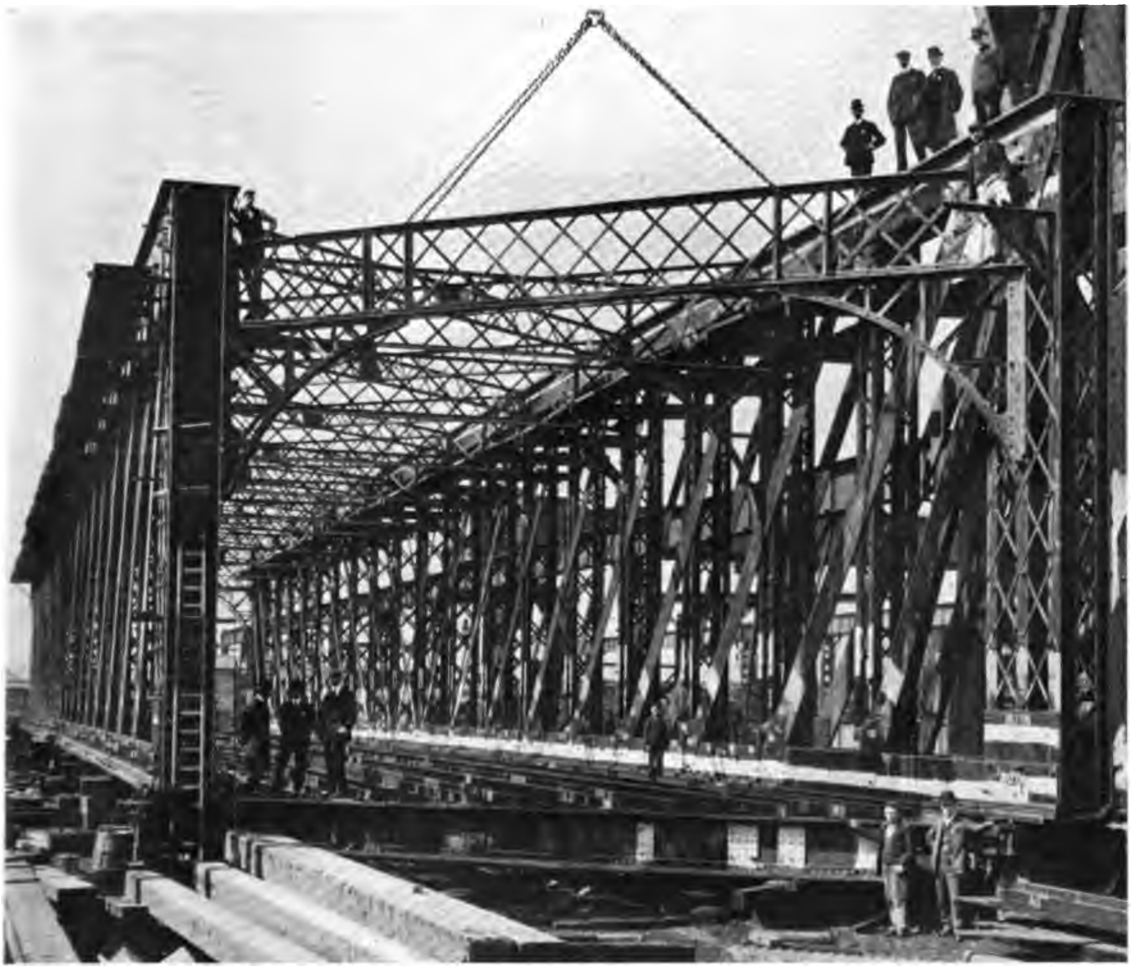
UNITED STATES.

The battleship *Maine* has undergone trials with satisfactory results, obtaining a maximum speed of 18·95 knots. She drew 23 ft. 6 in. and displaced 12,350 tons during the runs. The average number of revolutions per minute was 125. The boilers, of which there are 24, are of the Niclausse type. The complete armour belt is of Krupp steel, 7 ft. 6 in. wide, 11 in. thick above water between the turrets, and 7½ in. thick under water, tapering to 4 in. at the ends. The bulkheads are of 10-in. and the turrets 12-in. armour, while over the battery there is a thinner belt. The protected deck has a maximum thickness of 4 in. The total weight of the armour is 2,453 tons. The armament consists of four 12-in. breech-loaders mounted in pairs in the turrets, sixteen 6-in. quick-firing, two of them in casemates under the forecastle and the others in the maindeck battery, and twenty-four smaller guns, with two submerged torpedo tubes, one on each bow.

The Navy Department have invited tenders for an additional battleship, authorised by the Naval Appropriation Bill, and a sister vessel will be built in the New York Navy Yard. The contract vessel is to be completed within forty-two months. The length at the water line will be 450 ft. and the beam 76 ft. 10 in. The displacement on trial is not to exceed 16,000 tons. The armament will consist of four 12-in. breech loaders, mounted in pairs in two electrically controlled turrets, one forward and one aft, each with a firing arc of 270 deg.; eight 8-in. breech loaders, mounted in pairs in similar turrets at the corners of the citadel; twelve 7-in. breech loaders on the broadside, on pedestals behind 7-in. armour; the fore and aft guns to fire right ahead or right astern, the others to have the usual broadside train. Fifty smaller guns are to be mounted in commanding positions, having a large arc of unobstructed fire. The principal turrets are to have 12-in. plates in front and 8-in. in the rear, and the secondary or 8-in. gun turrets will have 6-in. armour. The total weight of the armament will be 945 tons, and 591 tons of ammunition will be carried. The protection of the hull will be provided by a complete belt 9 ft. 3 in. wide, and with a maximum thickness of 11 in. for about 200 ft. amidships, beyond which the thickness will be 9 in. over the magazine spaces, and will decrease to 4 in. at the stem and the stern. The lower casemate armour will extend in length to protect all the magazines and vital parts, and will rise to the lower edge of the 7-in. casemates, being 6 in. thick, with 6-in. athwartship bulkheads at the ends. There will also be an upper range of casemate armour 7 in. thick athwartships, extending from the shell plating to the 12 in. barbettes. In regard to the speed, it may be remarked that the contract is 18 knots, with 17½ knots as an absolute minimum, and the builder will be subject to a penalty of 50,000 dols. for the first ¼ knot deficiency, and twice as much for the second. There will be twelve Babcock and Wilcox boilers, with 46,750 square feet heating surface. The bunker capacity will be about 2,200 tons, but only 900 tons will be carried on trial. It is particularly deserving of note that in these two battleships the system of superposed gun turrets, adopted in the *Kearsarge* and *Kentucky*, abandoned in the *Maine* class, and resumed again in the *New Jersey* class, has once more been abandoned. It is also particularly noteworthy that the Americans are introducing eight 8-in. turret guns as a secondary armament, compared with four 9·2-in. in our latest class, and twelve 7-in. guns as compared with our ten 6-in. guns for the battery. The result is that the American secondary turret and battery guns will throw a weight of metal of 3,980 lbs., while our 9·2-in. and 6-in. guns will give only 2,520 lbs.

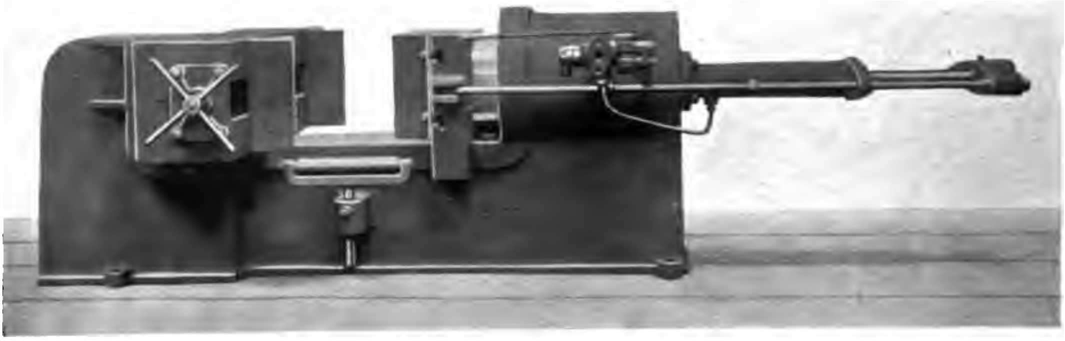
A board of officers presided over by Lieut.-Commander John R. Edwards is conducting a series of liquid fuel tests, in relation to which Rear-Admiral Melville says that oil can be used as fuel with facility, but that it cannot be employed economically in the United States Navy. He does not believe that there is any prospect of liquid fuel replacing coal except perhaps in small craft. The experiments are being continued.

NOTES & NEWS.



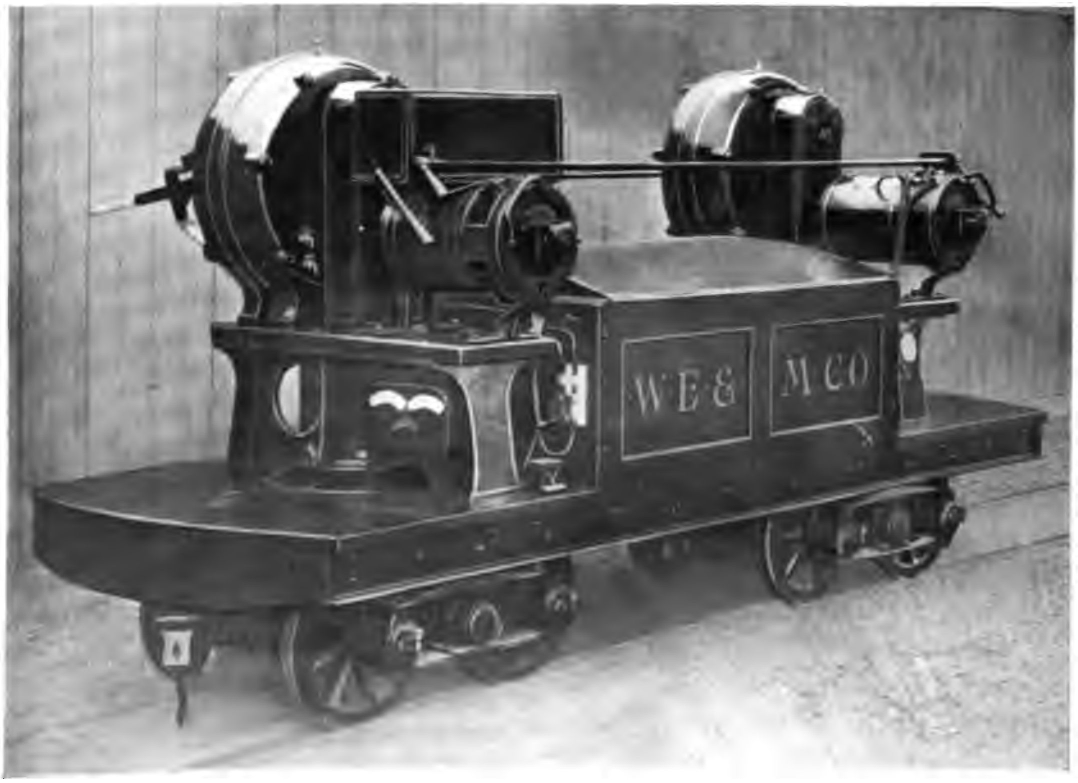
NEW BRIDGE OVER THE RIVER AIRE, NEAR FERRYBRIDGE.

This bridge, constructed by the Cleveland Bridge and Engineering Company, Ltd., Darlington, will replace the existing tubular bridge. It has a 250 ft. span, and the girders are 50 ft. high. The traffic in the river necessitated a water way with a clear opening of 60 ft. on the square. This, allowing for the towing path, involved temporary girders 50 ft. long.



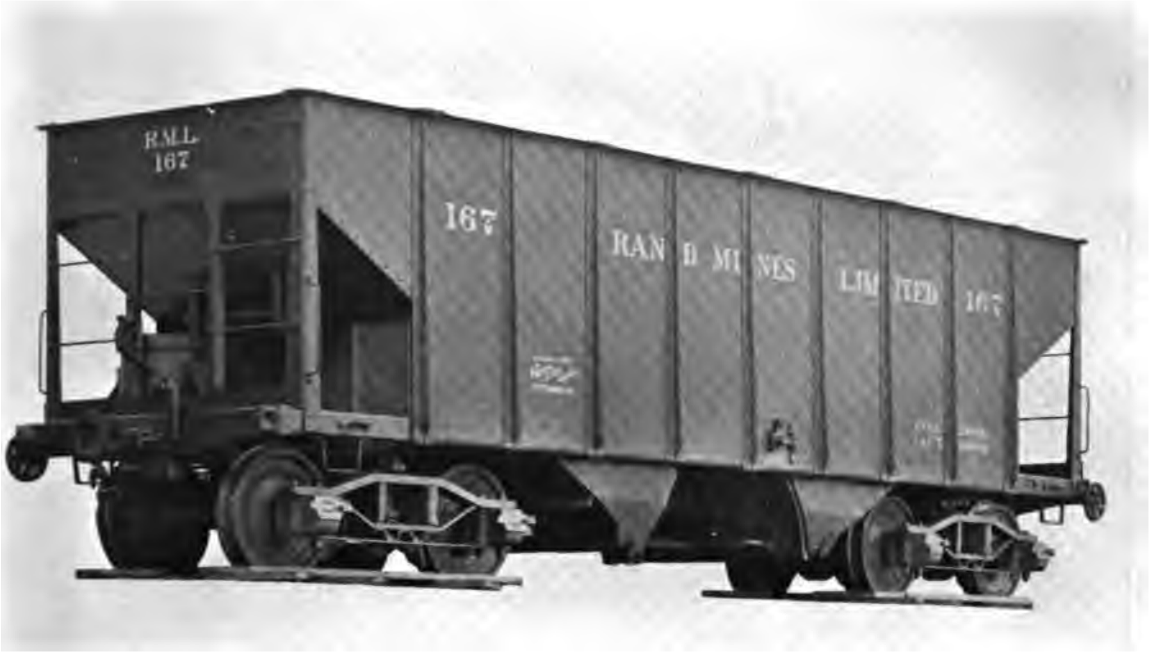
HYDRAULIC PRESS FOR STRAIGHTENING "H" GIRDERS, BENT AND TWISTED OUT OF SHAPE IN COAL MINES.

Mr. George Addy, M.I.Mech.E., of Sheffield, has recently demonstrated that, with his new hydraulic press, illustrated above, twenty-one bent girders can be straightened (cold) in 1½ hours. Formerly, it was considered a good day's work to straighten twenty girders, necessitating an expenditure of 2½ tons of coal, and the services of four men. With this press three men only are required. It weighs about 6 tons, the diameter of ram being 18 in.



NEW ELECTRIC LOCOMOTIVE.

A new Electric Storage Battery Locomotive, supplied by the C. W. Hunt Company, of Staten Island, New York, for the "industrial" railway installed at the Works of the Westinghouse Electric and Manufacturing Company, at East Pittsburg, Pa., U.S.A.



30-TON HOPPER WAGGON.

A 30-ton pressed steel coal hopper waggon, recently built for the Rand Mines, Ltd., South Africa, by the Transportation Development Company, 6, Clement's Lane, Lombard Street, E.C. Gauge, 3 ft. 6 in. Weight empty, 28,100 lbs.

Messrs. R. Waygood and Co., Ltd., and the Otis Elevator Company, Ltd.

An important amalgamation, consolidating the interests of these two companies, has been effected. Mr. H. C. Walker, chairman and managing director of Messrs. R. Waygood and Co., will be chairman, and together with Mr. R. Percy Sellon, M.I.E.E., managing director of the Otis Elevator Company, Ltd., will act as joint managing director of "Waygood and Otis, Ltd."

The consideration which appears to have determined the directors and shareholders of both companies in favour of uniting the two businesses is that each party is able to supplement the other in important respects, the Waygood Company possessing excellent manufacturing facilities, while the Otis Company controls for the British Empire and Europe, the patents, designs, and wide experience of the Otis Elevator Company of U.S.A. The British and American Otis Companies are quite distinct organisations, possessing only the name in common; but the British company is not only the proprietor of the American company's patents in its territories, but has the immense resources of the latter at its back.

Chain-Grate Stokers.

Messrs. Babcock and Wilcox, Ltd., have just secured from the Underground Electric Railways Company (of London), Ltd., at Lots Road, Chelsea, an order for 128 chain-grate stokers, which are to be used in connection with sixty-four of their boilers, recently sold to this company. This is the largest order for chain-grate stokers that has ever been booked at a time.

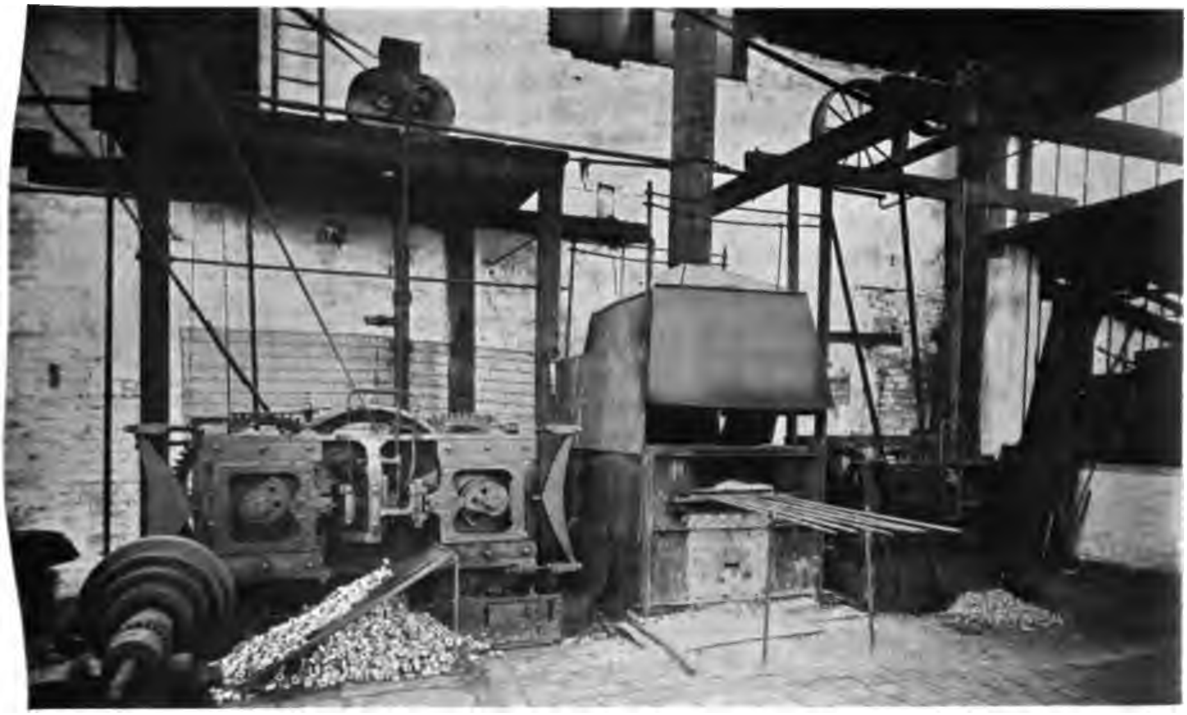
Ore Transport Waggons.

An order for 500 special 12-ton waggons, with steel underframes, has been given to Messrs. W. R. Renshaw and Co., Ltd., by the North British Railway Company. These waggons are to be used for carrying iron ore from the docks to the various iron works, and to convey coal back to the docks.

Körting Gas Engine.

Messrs. Fraser and Chalmers announce that they have secured the manufacturing rights from Messrs. Körting Bros., of Hanover, for the Körting Gas Engine, for use in plants connected with the steel industry, and that they are now prepared to build these engines in sizes up to units of 2,000 h.p.

They have also secured the manufacturing rights for the Stumpf-Riedler system of blowing engines to work in connection with these gas engines. One installation of a 500 h.p. Körting gas engine is now in operation at Duisberg, at the works of the Nieder Rheinische Hütte, and another of 1,000 h.p. at Donnersmark Hütte Works,



LIQUID FUEL FOR NUT-FORGING.

In the works of Messrs. Richard Davis and Sons, Manchester, liquid fuel has lately been successfully employed for heating bars for bolt and nut forging. A greater radiation than that obtainable from coal or coke has been thereby secured, in addition to a marked saving in cost. The bars are afterwards placed in the forging machine, a nut being made at every revolution.

in Germany. These are operating with blast furnace gases. A large order of twelve 2,000 h.p. Körting engines has been recently placed by the Delaware-Lackawanna Steel and Iron Co., of Buffalo, U.S.A.

It is interesting to note in this connection that the exhibition of the Körting system gas engine, with Stumpf-Riedler blowers, is one of the chief features of the Exhibition now being held at Düsseldorf.

Gas Producers, etc.

Messrs. W. F. Mason, Ltd., of Manchester, have been successful in obtaining the whole of the contract of the Bengal Iron and Steel Company, Ltd., for gas producers, connecting tubes, and coal staging for the new steel works plant.

Carborundum.

A test of the various makes of grinding wheels for abrasive purposes was recently made at the Technical High School of Dresden. The tests were conducted under the supervision of Professor Grubler, of the Technical High School, and were intended to demonstrate the operative strength of different makes of wheels Three carborundum wheels were furnished for this test, and these wheels broke the record as to speed, as they were run at 4,340 revolutions per minute. These wheels were made by the vitrified process, and they made a better record than any vulcanised wheels tested. Wheels made by the best manufacturers of emery wheels broke at speeds of 2,720, 2,700, and 2,620 revolutions per minute.

Refuse Destructors.

The judges of the Sanitary Institute have, at the Exhibition in Manchester, awarded the Horsfall Destructor Company, Ltd., the Institute's silver medal (the only award) for their improvements in refuse destructors.

WATER-TUBE v. CYLINDRICAL BOILERS.

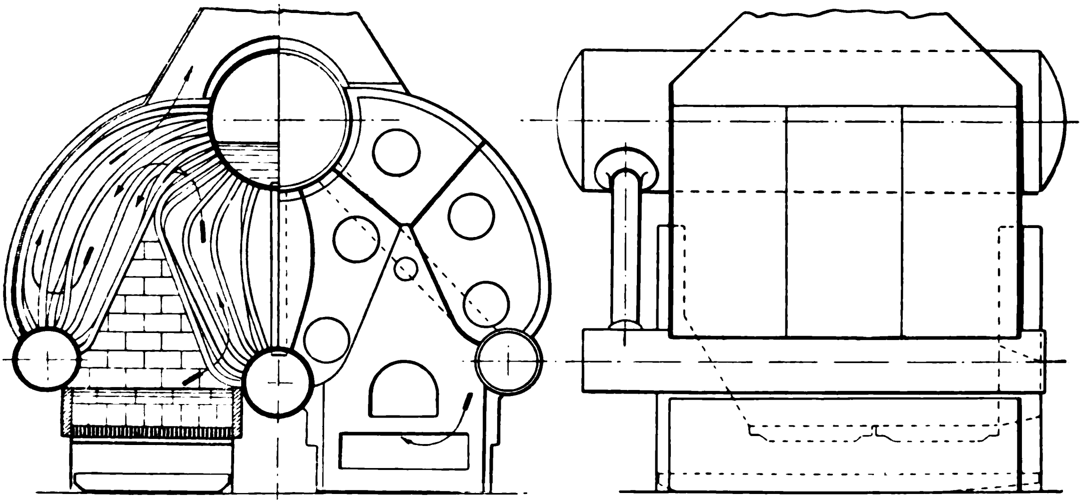
There is probably no more important factor in the efficiency of our first line of defence than the boilers of our vessels of war. Boilers are to the steamship what lungs and heart are to the human being. Upon their soundness depends not only the mobility but the actual existence of the steam vessel, and it is therefore not at all to be wondered at that the subject of naval boilers has occupied during the past two or three years a position of the first importance, not only in the many discussions which have taken place in Parliament during the debates on Navy Estimates, but also in the columns of the press. The following articles—one by an eminent naval engineer, the other by a prominent maker of cylindrical boilers—consider the question "Water-Tube v. Cylindrical Boilers" from diametrically opposite points of view.

WATER-TUBE BOILERS, FROM A NAVAL POINT OF VIEW.

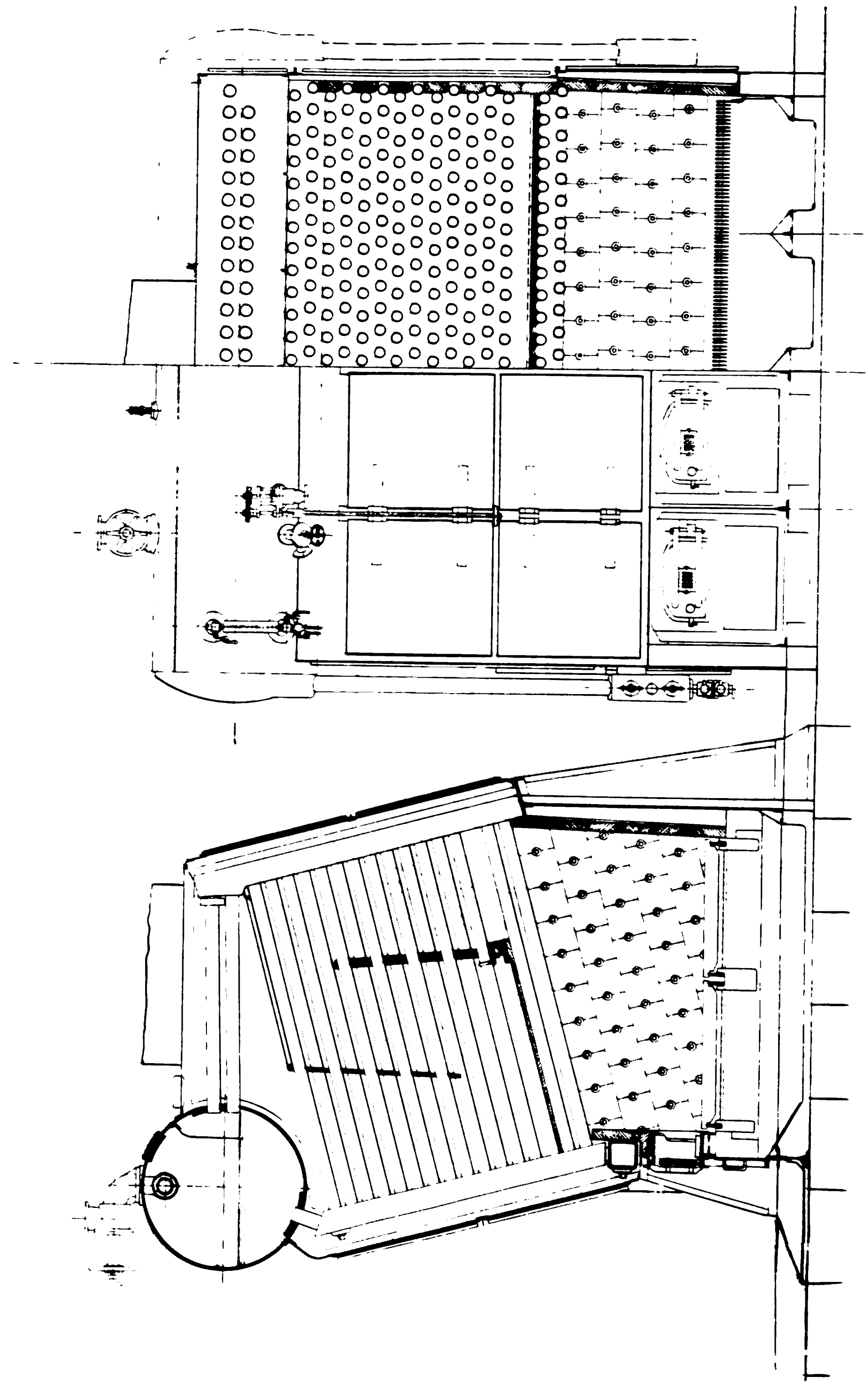
WATER-TUBE VERSUS CYLINDRICAL BOILERS.

THE advantages of water-tube boilers for warship service have met with such general recognition that in one form or another they have been introduced into all the navies of the world. There are, of course, certain points in which they may be inferior to the older types of cylindrical boilers which they are now replacing, but it is the deliberate conviction of the greater majority of people who are competent to give an opinion on this all-important matter, that water-tube boilers have come to stay, and that cylindrical boilers will in future occupy a very inferior position in all war vessels. Indeed, it is probable that in course of time they will be altogether abandoned.

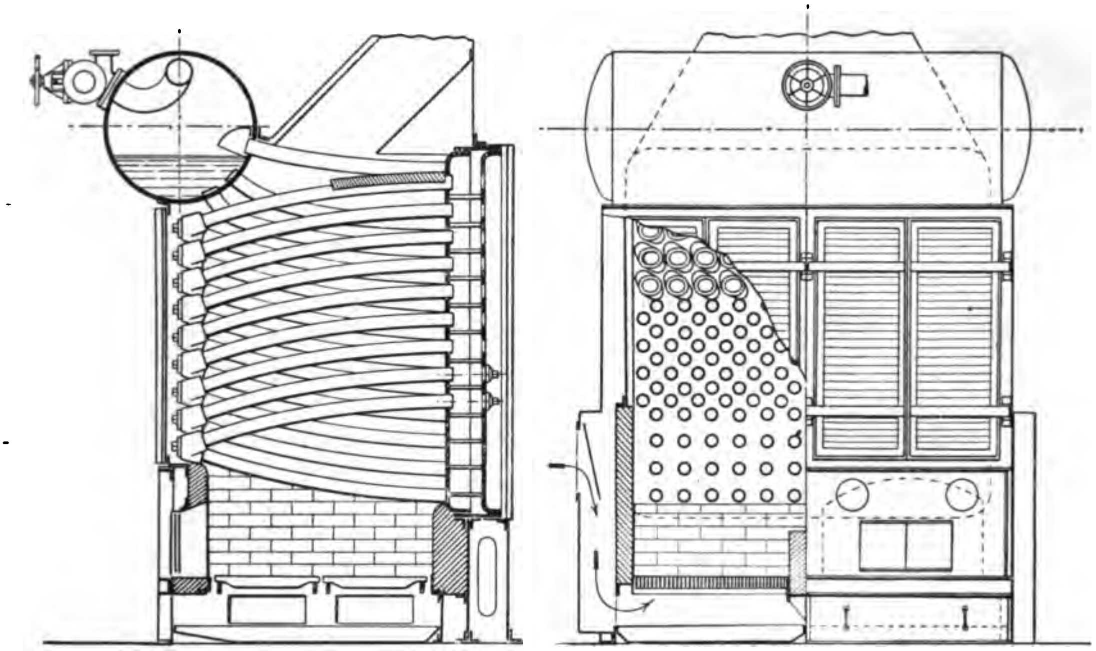
On making a careful comparison between water-tube and cylindrical boilers, we find that



SCHULTZ FORM OF THORNYCROFT BOILER.



TYPE OF BABCOCK AND WILCOX WATER-TUBE MARINE BOILERS AS FITTED IN THE ROYAL NAVY.



THORNYCROFT-MARSHALL BOILER IN COURSE OF CONSTRUCTION.

the former will raise steam more quickly and maintain it more evenly and at much greater pressure. They can be much more easily renewed or repaired, without having to lay up the ship or pull up her decks for this purpose. They are not so dangerous in action, and will not suffer so seriously from small projectiles. The effect on the ship's company will not be so disastrous in the event of an explosion, because they contain only a very small amount of water for steam generation. They are very much lighter and produce more horse-power per ton of weight, and thus enable advantages to be secured either in speed of vessel or in the amount of armour, armament, or coal supply. They can be "forced" or made to produce a greater quantity of steam for longer periods, and can therefore continue steaming at higher powers, and in this connection also they are assisted by a larger fire-grate area, which enables them to maintain steam for their maximum powers with greater facility.

DISTRIBUTION OF POWER IN WATER-TUBE BOILERS.

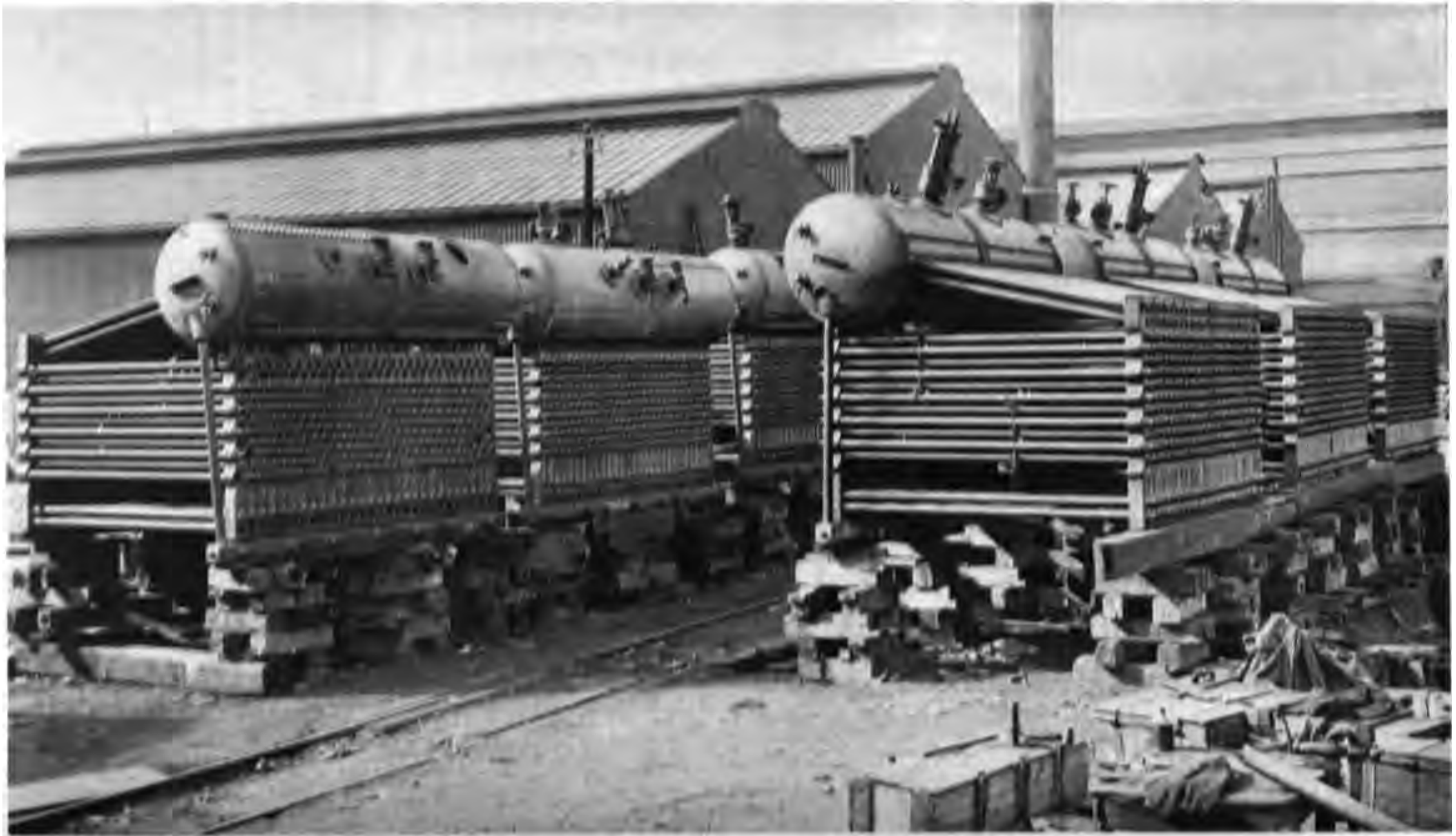
The installation of a water-tube boiler system in a war vessel is always accompanied by the very decided advantage that the total power is distributed amongst a much larger number of boilers than is the case with the older system. Thus a modern cruiser, which would be fitted with twelve boilers of the cylindrical types, would spread its power over about thirty water-tube boilers, and hence the total or temporary disablement of one of the latter would have scarcely any appreciable effect upon the speed of the vessel, whereas if she were to lose one-twelfth of her steam generating power by an accident to one of her cylindrical boilers, there would be a very considerable diminution in her rate of progress.

ALLEGED DISADVANTAGES.

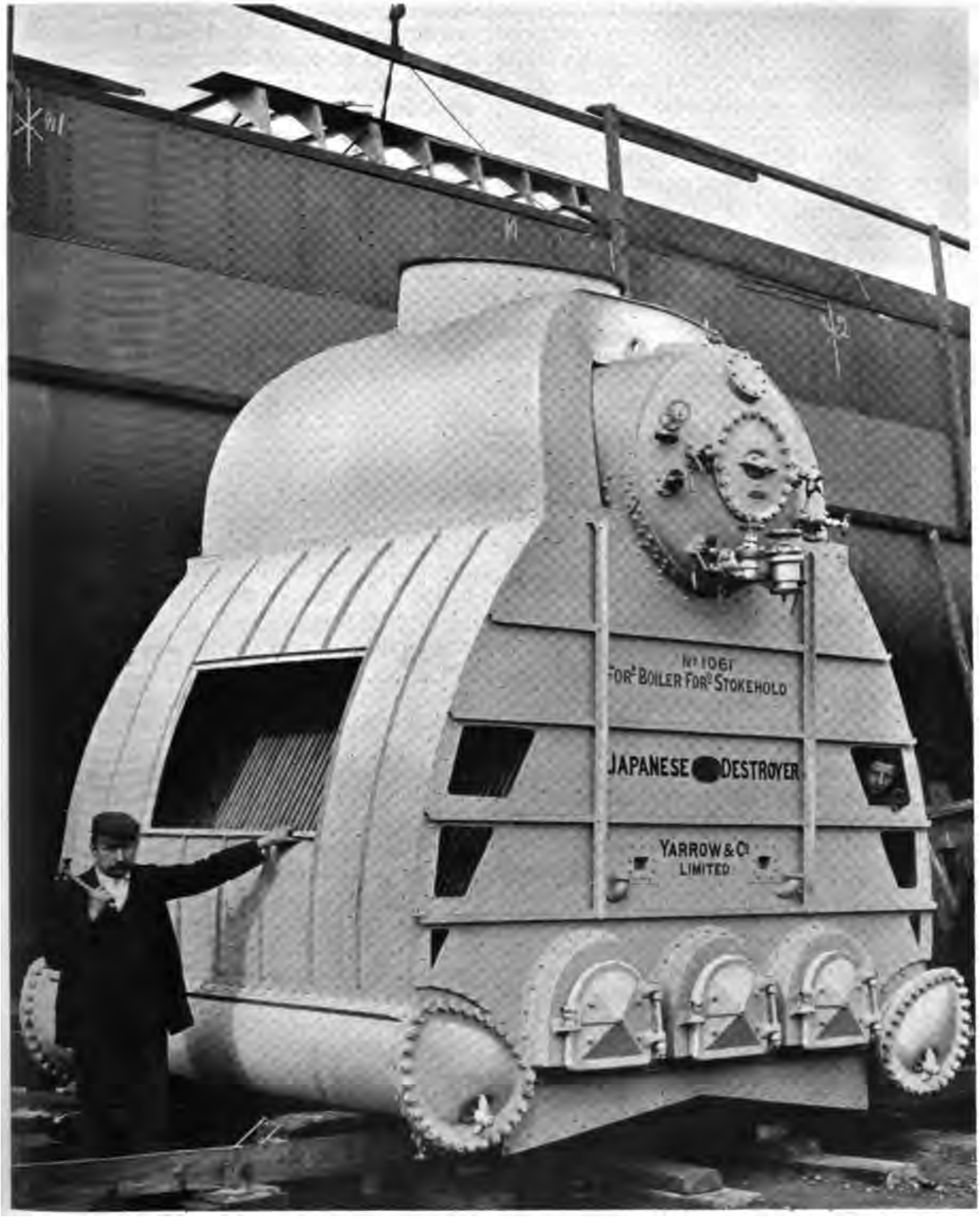
The alleged disadvantages of the water-tube boilers are: That they are less economical in coal consumption per unit of power, that they require more careful stoking, that the cost of their upkeep is greater, that a larger mechanical staff is necessary in order to keep them in repair on account of the necessary multiplication of their fittings and mountings, and that higher engineering skill and attention are necessary for their management and maintenance than is the case with cylindrical boilers.

THE WATER-TUBE BOILER COMMITTEE.

In spite of these alleged disadvantages, however, there is no doubt that for war vessels the



PRESSURE PARTS OF BABCOCK AND WILCOX BOILERS FOR SEA-GOING DREDGER "SAMSON."



A YARROW WATER-TUBE BOILER, CAPABLE OF DEVELOPING 1,600 H.P.

balance of advantage lies considerably with the water-tube boilers. This was amply confirmed by the investigations of the Water-tube Boiler Committee appointed by the First Lord of the Admiralty in September, 1900. After a few months' labours the members of the Committee were asked to furnish an interim report, in order to satisfy the earnest desire of the House of Commons and the country generally for *bonâ-fide* information. There was at the time some doubt as to the wisdom of the Government in demanding such a report, but as many new vessels were about to be constructed, it was absolutely necessary to come to a decision about the class of boiler with which they were to be fitted. In the interim report, which was forwarded to the Admiralty on February 19th, 1901, it is stated that "the advantages of water-tube boilers for naval purposes are so great, chiefly from a military point of view, that, providing a satisfactory type of water-tube boiler be adopted, it would be more suitable for use in H.M. Navy than the cylindrical type of boiler."

ITS INTERIM REPORT CONFIRMED.

On May 28th, 1902, on the departure of Admiral Sir Compton Domvile, who had been acting as the president of the Boiler Committee, to take up the post of Commander-in-Chief of the Mediterranean, another report, intended to be final upon most of the points which had been referred for the consideration of the Committee, was issued. In this later report the members of the Committee state that further experience has confirmed them in the opinions which they had previously expressed in their interim report of February 19th, 1901; and so it appears to be settled as finally as it is possible to determine such a matter that the water-tube boiler, of some type or another, is to be adopted as the successor of the cylindrical type. This is the deliberate decision arrived at by a Committee of practical engineers of considerable eminence in their profession. They could not possibly be suspected of any bias in favour of the water-tube boiler, and in this connection it is as well to remember that the Committee owed its very existence to persistence, and, as far as possible, complete discussion in the House of Commons. The opportunities of the Water-tube Boiler Committee for obtaining evidence, making practical investigations, and arriving at a sound decision have been unique. The few members of Parliament who pressed their demand, in season and out of season, for an independent inquiry into the system of boilering our warships, are to be congratulated upon their perseverance and patriotism, no less than upon the success which has attended their endeavours.

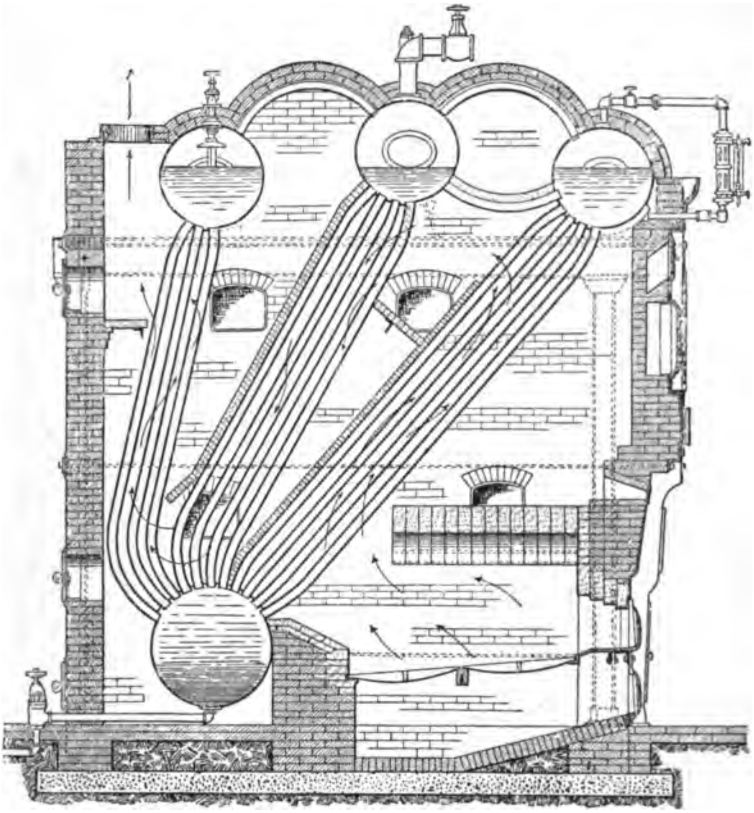
A BOLD DEPARTURE.

The introduction of the water-tube boiler on the large scale adopted in the two huge cruisers *Powerful* and *Terrible* in the year 1895 was the boldest departure in naval engineering practice on record. It was, as might have been expected, attended with much solicitude, and perhaps at times, much excusable doubt in the minds of responsible naval authorities who were not engineers. That in spite of this, the Engineer-in-Chief of the Fleet, after such consideration as he deemed necessary, took upon himself the enormous responsibility of advising this radical and bold departure, redounds infinitely to his sagacity and credit.

INTRODUCTION OF THE BELLEVILLE.

The battle of the boilers may be said to have commenced with the introduction of the Belleville boiler into our vessels of war in the year 1895, but long previous to that date we had adopted water-tube boilers of the small tube type for use in "destroyers." In fact, without a boiler of this kind, the existence of the fast and fragile "destroyer," as we know it to-day, would have been an impossibility. No other type of boiler, except the "express" or water-tube type, would have given the rapid and easy method of steam generation, or would have possessed the merits of extreme lightness and adaptability of being fitted into small vessels.

The destroyer *Havock*, the first of her class, was originally fitted with locomotive boilers, and she was looked upon as the best example of what could be done in vessels of her type; but the performances of the *Havock* have been far surpassed since by vessels which were fitted with the small tube type of water-tube boiler. A very notable case is that of the torpedo gunboat *Speedy*, a small vessel of 800 tons displacement, built by Messrs. Thornycroft, who guaranteed to supply a horse-power



SECTIONAL VIEW OF STIRLING BOILER (UNITED STATES TYPE).

of 4,500 instead of the 3,500 obtained with locomotive boilers in similar vessels of her class, and to do it on a smaller weight of boilers, which should also occupy less space. The saving of weight of water alone in the boilers of the *Speedy* was 20 tons, a very valuable feature considering the important part which weight plays in small, fast vessels of this class. The *Speedy* was a triumphant success, and the adoption of small water-tube boilers for the torpedo gunboats, torpedo boat-destroyers, and all classes of torpedo boats became general.

The evolution of the large, fast war cruisers, such as one now sees in the navies of all the important maritime Powers, would have also been impossible without the adoption of a water-tube boiler of some kind or another. For fifteen years or so prior to the introduction of the Belleville boilers into the British Navy, France had been using them in the vessels of her mercantile marine, and had also adopted them for her war navy. It was the only kind of large tube water-tube boiler of which any extended experience had been obtained, and, therefore, having become convinced that a water-tube boiler was an absolute necessity for a war navy, the British Admiralty were perfectly justified in selecting the only boiler of the kind of which anything was known.

UNREASONING OBJECTIONS.

The troubles which have attended its introduction into our service have been seized upon as a reason for objecting to its use altogether. The most wild and unreasoning statements have been made against the alleged unsound practice of boiling water in a tube, by the adherents of the old boiler system, who forget that, after all, a cylindrical boiler is merely a tube on a larger scale. The soundest engineering practice is that which can obtain the best result, and leave the balance of practical advantages on its own side, and this is undoubtedly procured by the water-tube boiler.

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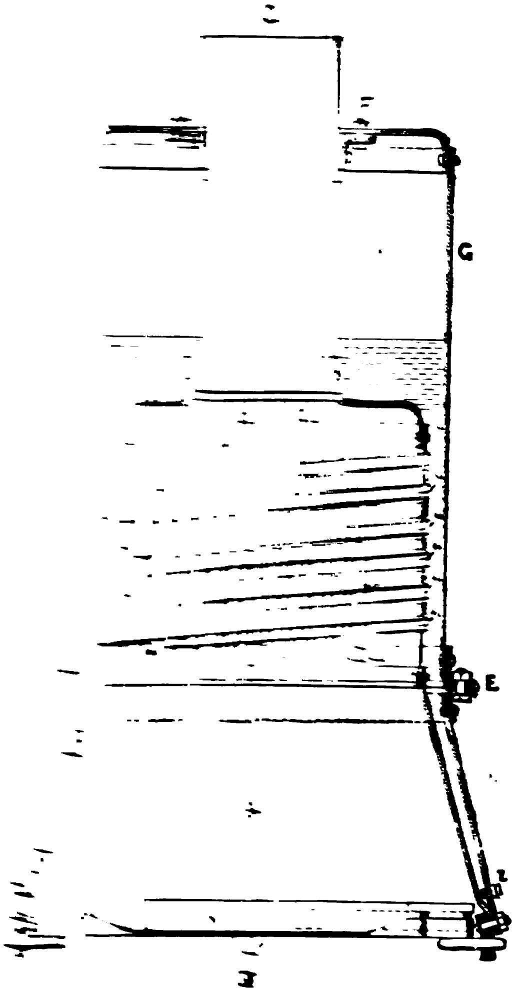

[illegible] ING BOILER, FOR [illegible]

[illegible] AND SONS, LTD.

[illegible] between the engineering methods [illegible] are respectively adopted to suit the conditions of a war navy and of a mercantile navy must in the highest degree be misleading and fallacious. The difficulties which have attended the introduction of large water-tube boilers into the Navy have been intensified by the magnitude of the new departure, by the shortage of officers and men of the engineer branch, and by lack of training of the engineer staff in the care and management of these boilers.

The early experiments with the *Sharp*-*shooter*, which was fitted with a small installation of Belleville boilers, and the steam trials and subsequent experience of the two large cruisers *Powerful* and *Terrible*, gave every encouragement to the Admiralty to fit the Belleville boiler into all succeeding vessels. In the earlier cases just mentioned it had been found possible to detail a large percentage of their engine-room complements for duty in the vessels before they were required for commissioning, and although it was only natural in a new system adopted on such a large scale that some difficulties should be met with, there has never been any serious trouble with the boilers of these ships. One of them having already completed a foreign commission, is now again ready for service with the same boilers which were placed on board her in 1895-6, while the other, after having been nearly four and a half years in commission, is just returning from service on the China station.

NECESSARY CONDITIONS.

It is a necessity with an installation of any kind of water-tube boiler that there should be an ample supply of feed water of the purest kind, and to ensure this there should be great care exercised in the design and manufacture of reliable and tight condensers, and the provision of suitable evaporating plant to supply an adequate amount of feed water for the boilers. Troubles which have occurred in many ships owing to leaky condensers, loss of water by leaks from defective steam pipe joints, drains, imperfect workmanship and other causes, are now nearly eliminated, while the longevity of the boilers is being increased by the extra experience which those entrusted with their management are gaining in their care and preservation. The recent report of the Water-tube Boiler Committee is to some extent disappointing, because, while it condemns the Belleville boiler, it does not definitely suggest any other type of water-tube boiler in its place.

THE BELLEVILLE SCARE.

The Belleville boiler has been condemned because up to the present it has been the only type of large water-tube boiler in our Navy with which the Committee have been able to experiment on any scale, but while the members of the Committee have been deliberating, the boilers themselves have been giving much better results as officers and men have gained experience with them. The troubles which have occurred in our Navy with Belleville boilers would have occurred with any other class of water-tube boiler under similar conditions, and they are all connected with causes which lie outside the boilers themselves, and which are now in process of elimination. It is not the purpose of this article to proclaim the merits of any one particular type of water-tube boiler, and if the experience which will be obtained in our new cruisers with the "Babcock and Wilcox," the "Niclausse," the "Dürr," or the "Yarrow" large tube boiler, all of which have been recommended for trial by the Boiler Committee, proves that any one of these types is superior either to the Belleville or to the others, then by all means let the Navy be supplied with the best type we can get. But, in the meantime, there is no reason for alarm, because about sixty or seventy of our largest vessels of war are fitted with the Belleville boiler, which has up to date had to bear the brunt of the battle of the boilers in our Navy. Nearly all engineer officers of the Navy who have had practical experience with this class of boiler prefer it greatly to the cylindrical boiler. The objections of other naval engineers are more theoretical than practical. Admirals Sir John Fisher and Lord Charles Beresford, who have recently returned to England from the Mediterranean Fleet, have probably between them given that squadron more hard and continuous steaming than has fallen to the lot of any other fleet in the world, and in all such cases the ships with water-tube boilers have made the best performances, and have been the most reliable steamers.

CONCESSION TO PESSIMISM.

The phenomenal success obtained in the trials of the four mighty cruisers of the *Leviathan* class, each of which developed easily 30,000 horse-power and attained a speed of over 23 knots per hour, and the more recent trials of the three cruisers, *Powerful*, *Spartiate*, and *Europa*, which have taken place lately in the English Channel, should reassure the public mind on the matter of water-tube boilers. The statement of Admiralty policy which was recently made by Lord Selborne in the House of Lords, leaves no doubt that those responsible for the efficiency of the Navy consider that the water-tube boiler is the best suited for naval needs. The decision to fit the new cruisers of the *Devonshire* class with a combination of one-fifth cylindrical and four-fifths water-tube boilers is a concession to pessimism and sentiment. The practical difficulties in its working probably will be found to overcome its supposed advantages.

WANTED—INCREASED SKILL.

If more than ordinary skill be required for the satisfactory working of water-tube boilers, then it is the duty of the Admiralty to insist on a thorough and comprehensive system of training for the naval engineer *personnel*. Every advance in a science or subject must be paid for in one way or another, and if increased skill and attention be the price required for the undoubted advantages of the water-tube boiler for war vessels, there is plenty of the highest engineering talent in the country which can be obtained, if the Admiralty will only take the proper means to secure it.

CYLINDRICAL BOILERS FROM AN ENGINEER'S STANDPOINT.

According to the evidence taken by the Committee, no type of water-tube boiler at present in use is on general service so economical as the cylindrical. The Committee themselves express the opinion that retarders will be found in many cases to render existing cylindrical boilers even more efficient and economical than they are at present. Until a thoroughly satisfactory water-tube boiler is obtained, the Committee recommend that in large cruisers and battleships cylindrical boilers of sufficient power to work the auxiliary machinery, and to drive the ship at her ordinary cruising speed, should be used with the same steam-pressure as for the water-tube boilers, say 210 lbs. per square inch.

The cylindrical boiler, then, is not played out, and in so far as the merchant service is concerned, nothing so good and serviceable has yet been devised as the good old "Scotch boiler," which superseded the "tank," and which still deserves its name for efficiency, reliability, and persistency, whether or not the time has come for some improvement in the steam-generating plant of sea-going steamers. It has been often said that the progress made in boiler equipment (the most costly and perishable part of the outfit of a steamer) has not been commensurate with that in engine practice. This is not quite true. Fifteen or twenty years ago, eight years was considered a good average life for a marine boiler; to-day, twenty years is a by no means uncommon age. The type remains, but mechanical progress does not necessarily involve change of type. The Scotch boiler was undoubtedly the founder of the success of the marine engine as we now know it.

The first high pressure Scotch boiler was fitted into the first triple expansion steamer in 1881. This was the *Claremont* of Newcastle-on-Tyne, whose engines were built by Messrs. Douglas and Grant, of Kirkcaldy. Previous to that no boiler builder would undertake to build a boiler for 150 lbs. pressure. The determination of the qualities that go to make up efficiency has not, perhaps, been quite so familiar a study as it ought to be. It is not so many years since the shearing strength of a rivet was considered equal to its tensile strength. Apart from developments in the art of the boiler-maker, however, he has now at his command better materials than ever were known before. If a perfect boiler can be evolved at all, it should be evolved now, when we have the perfection of material and the highest natural and inherited results in scientific insight and technical applications. As far as material is concerned, there is no reason why a boiler should not last thirty or forty years.

The essential condition for all boilers is, of course, that they shall have sufficient structural strength to withstand the ordinary working pressure. But they should also have a margin beyond this, to enable them to work with efficiency even when some parts become thinned by corrosion. Then they should be so designed as to withstand continuously the effects of expansion and contraction resulting from the changes of temperature, not only as to the whole structure but also as to special parts. The design should admit of the furnaces, flues, etc., being readily cleaned, and should provide for the free discharge of the steam produced from the heating surfaces. It is further desirable that the furnaces, flues, etc., should be so arranged as to admit of perfect combustion of the fuel, and of the ready transfer of the heat from the products of combustion to the water or steam in the boiler; for upon these matters economy largely depends. Facility for cleaning the whole of the inside of the boiler is of essential importance. The capability of being "forced," which is possessed by some types, is a distinct advantage. The rapidity with which steam can be raised or lowered, depending largely on the total quantity of water contained in the boiler, and the power obtainable on a given weight, or in a given space, or on a given floor area, are also qualities demanding consideration, as well as the ease with which a defective tube can be plugged or replaced, or other small repairs effected. In the selection of a boiler for any particular service, therefore, all its qualities must be considered, and the type selected should be that which will give more advantages than disadvantages.

In the case of the so-called "Scotch," or cylindrical multitubular boiler, the grates are arranged in circular flues or furnaces, extending from the front of the boiler for six or seven feet into the interior. The flames and hot gases from the fuel rise at the end of the furnace into the flame chamber, which varies in height with the size of the boiler, but is as a rule from two to three feet in width. The tube is one of the walls of this chamber, and it is pierced with holes, through which the tubes are fitted to the front plate of the boiler. When the flames and hot gases from the flame chamber pass through the tubes running parallel with the furnace, the heat so distributed generates steam from the water around the tubes. From the front of the boiler the hot gases and smoke are guided by the smoke-box to the funnel. The tubes are connected with the tube plate by the forced expansion of the metal, which is fitted in cold, and this is where leakage is apt to take place, as the result of the continual play of the flames on plate and tubes. The connection has been found sufficient for ordinary circumstances. But when forced draught is used the cold air rushes in with the hot gases when the furnace door is opened, and causes sudden and violent changes of temperature, by which the tube plate is affected. In a steamer, when the boilers leak under hard pressure of forced draught, the steam may find its way into the furnace and drive the flames out into the stokehold, with serious danger to life and limb of the stokers.

In naval construction the fault seems to have been first in reducing the size of the boilers to save weight, then in introducing forced draught, and then in expecting too much from the boilers as the result. In the merchant service Scotch boilers are generally used with natural draught, though forced or induced draught is frequently applied to them, but in the Navy forced draught is always employed at full powers.

The cylindrical boiler is probably the best in use as far as completeness of combustion of coal is concerned, when worked under ordinary conditions. With skilled attention it is possible to obtain results showing fairly complete combustion in almost any boiler. But as in this boiler all the gases from the front of the fire have to pass over the rest of the fire, meeting at right angles to the streams of gases coming through the back part of the grate, if the fire is of uneven thickness from careless stoking the gases have a probability of mixing together. before passing over the bridge into the combustion chamber, to enter which they have to take a sharp turn at right angles, which again assists them to commingle; and in the chamber they have further opportunities of mixing. Thus the unburned gases become largely consumed before they can get into the tubes, where their temperature is quickly lowered below the ignition point, and no further combustion is then possible. All combustion, then, must take place either in the furnace or in the combustion chamber.

This boiler, further, being less dependent for economy upon careful stoking than most of the other types, has not so much necessity for incessant watchfulness as regards the water supply. The free water area is large, and in ordinary working there are several inches of water above the heating surfaces, so that a considerable amount of water may be evaporated after the stoppage of the feed supply, before dangerous consequences ensue. The roomy steam space and large volume of water contained in the boiler also act as reservoirs of energy, and considerably modify the effects of irregular or careless stoking. This is why Mr. J. T. Milton, of Lloyd's, says that this boiler can be worked with a fair amount of success under conditions [illegible] be considered

[illegible] These are some of the con- [illegible] show that the design of boiler [illegible] the vessel might not neces- [illegible] be the best suited for the others. The [illegible] of the different classes of war vessels [illegible] are not the same, so that it by no means [illegible] absolutely necessary in, say, [illegible] would be suitable [illegible]

[illegible] engine or boiler, [illegible] merchant shipowners [illegible] is thereby assured; [illegible] further advance in [illegible] must be remembered [illegible] pressures above the [illegible] lbs. and 200 lbs. [illegible] likely to give such [illegible] economy in the engine as [illegible] in the past by increases above [illegible] pressures formerly used.

[illegible] service the boilers used are [illegible] universally cylindrical, with internally [illegible] smoke-tubes. The pressure [illegible] lbs. per square inch, although in some cases [illegible] lbs. per square inch has been [illegible] and in a few cases even up to 250 lbs. [illegible] repairs and renewals of these boilers are serious matters, it is necessary that they should last for many years, but it is also important that they should be economical in fuel consumption. This, indeed, is the motive which has led to the gradual increase of steam pressure to the present point, which many engineers consider to be the maximum which can be obtained with this type of boiler. If water-tube boilers are to supersede the cylindrical in merchant steamers, they will have to be proved to be at least as economical in fuel consumption in proportion to the evaporation obtained, and new types of engines will have to be made to utilise properly the higher pressures of steam the water-tube boilers will render available.

Experts differ, of course, as they always do, as to the cause which brings about leakages. One theory is that the fault is due to a want of elasticity in the tube-plate, and that it ought to be much thinner than it usually is. Experiment has shown that the part of the tube-plate nearest to the fire expands more than the upper part, thus giving the plate a tendency to curve, and the contention is that tubes of equal length connected with the plate must become distorted when the plate curves, besides the molecular strain on the tube-plate due to the two sides being subjected to different temperatures. Others, again, contend that the strain which causes the leakage is due to the tube-plate being overheated in consequence of deficient water circulation in the boiler, and especially immediately inside the tube-plate.

Some of the experiments of Sir A. J. Durston, Chief Engineer of the Royal Navy, were made with a view to proving this. A few years ago he applied forced draught and an improvised arrangement corresponding to a boiler, until the tube-plate became red-hot at 1,400 deg. F., and when the boiler was cooling there was leakage. The point to which the tube-plate in this case could be heated without subsequent leakage was 750 deg. F., and it was ascertained that a deposit of grease inside the boiler resulted in a loss of efficiency to the extent of 8 to 15 per cent. Tests were also made to ascertain the temperature of the gases in their course from the fire through the tubes in a small boiler. Starting at 1,644 deg. F., in the combustion chamber, they entered the tubes at 1,550 deg. When they had passed over 1 in. the temperature was 1,466 deg.; at 2 in., 1,426 deg.; at 3 in., 1,405 deg.; while at 8 in., it recovered to 1,410 deg., and at 14 in. dropped to 1,368 deg., continuing to fall to 887 deg. at 6 ft. 8 in. Two-elevenths of the fall, therefore, took place in the first 2 in. of the tube, so it is quite evident that the greatest generation of steam is in the vicinity of these two inches, or practically close to the tube-plate. If the water there does not circulate satisfactorily there is a tendency to overheat.

A discussion of all the theories, however, is too large for our present purpose. Many engineers look very hopefully on the tubular-boiler, not so much on account of the defects in the multi-tubular, as of the objections to its weight and the weight of water it contains—objections which, of course, have most strength in regard to high-speed steamers. There are two fixed and distinct classes of water-tube boilers, those with large tubes and those with small tubes. The former have found most favour where considerations of weight are not extremely urgent. It is noticeable, however, that of recent times the tendency in large tube types has been towards a smaller size of tube, and in the small tube type towards a somewhat larger size.

ESTIMATES.

BY

CLAUDE W. HILL, ASSOC.M.INST.C.E., M.I.E.E.

A GOOD system of prime costs is a great help in the preparation of estimates, especially as a guide to the probable cost of labour, and a correct system of ascertaining the percentage of standing charges to be added to the bare cost of material and labour is of great importance. In many cases in which losses in trading have been incurred, analysis has shown that estimates as a whole have been correctly made so far as actual cost of material and labour have been concerned, but that the prices taken have been too low owing to the percentage added to cover standing charges being under estimated.

It is advisable that all estimates should pass through the hands of one man, who, for convenience, may be called the estimate clerk, although he should, in addition to clerical experience, have been through the works and have a good technical knowledge of the machinery, etc., with which he has to deal. Such a man is necessarily more expensive than an ordinary clerk, but the difference in salary is made up many times over in the avoidance of blunders with the losses which they entail.

All tenders should be made out on a special form, such as Form No. 10, and are preferably

TENDER.
Form No. 10.
No.......................   ....19....
M... ....
....

Dear Sir,

In reply to your esteemed inquiry of .... inst., our price for a Dynamo Electric Machine to work as................. . . to be our...........Type, size...........capable of developing...............@...............Volts at a speed of.......... ..... . Revs. per Minute, in accordance with accompanying Specification and Tracing No.............will be as follows:—

	£	s.	d.		£	s.	d.
Price of Machine alone..	,,	,,		Price of Starting Switch	,,	.	
,, Slide Rails	,,	,,		,, Regulating ,, ...	..	.	
,, Third Bearing	,,	..		.. Reversing ,, ...	..	.	
,, Extra Rail for Third Bearing	..	,,		,, Combination Bedplate and Coupling to Engine.. ..	..		
.. Flywheel	,,	,,					
,, Regulating Resistance for Shunt..	,,	,,					

Packing............................Carriage............................Delivery within.. ....from date of Order
Terms of payment.. ....
....
....

We trust to receive your Order, which shall receive our best attention and thanks, and remain, yours faithfully.

....

of such a size that three can be copied on one page of an ordinary foolscap copying book. In this book the tenders only should be copied, and one tender only should be copied on each page. Thus two-thirds of each page are left blank after the tender has been copied, and this blank space allows for the copying of amended tenders or for the entering of special information. Each morning all inquiries are handed to the estimate clerk, who, on receiving them, turns to his press copy Tender Book and gives each inquiry its future Tender Number. Thus, suppose the Tender Book in use is No. 2, and the last page on which a tender is copied is 120, he will number the inquiry letters E2/121, E2/122, etc., and as he does so he will tick off the corresponding leaves in the book to indicate that they have been taken. The Tender Number should be quoted in all correspondence and other papers relating to it, so that at any future time the whole matter can be easily traced out if necessary.

An inquiry may be for a machine of standard pattern, a machine of special design, or it may be for a complete contract comprising various sizes of standard machines, special machines, erection at site with steam and water pipes and other accessories.

FREIGHT CHARGES.

For standard machines the clerk will keep a tabulated record of costs and net prices, and to these he will add such amount for packing, carriage, etc., as each case may demand. For the determination of railway charges, very convenient books may be obtained, which give for any town the railway rate for goods of any class to any other town served by the railways. Similar books may be obtained for dock charges. It is very important that these should be borne in mind in cases where goods are to be delivered F.O.B. Firms not accustomed to delivering F.O.B. very often assume that as railway charges include delivery (within a reasonable radius) to any factory or warehouse they also include delivery to a ship. This is not so; as the railway company only deliver to the dock and the dock company handle the goods and put them on board. Thus a sum must be added to the railway charge to allow for delivery F.O.B. The charges in different ports and for goods of different classes vary, but ought always to be kept in view.

DRAUGHTSMAN'S QUANTITIES.

Form No. 5. ....19......

Tender No...........

For..

Dg. No.	Description.	Cast Iron. cwt.	Steel. cwt.	Gun-metal. lbs.	Brass. lbs.	Copper. lbs.	
	Totals........						
	Finished parts from stores entered here..........						

CATALOGUE LABEL.

Form No 78.

Size................ No................. Cor. No................
Name..
Subject..
Date............................... Edition...........................

Form A.

Richard Thomas & Henry.
Steam Valves. Catalogue 4 to No. 125.
Correspondence No., 308.
Discount 33⅓ per cent. and 2½ per cent. month.

Form B.

Steam Valves.
Richard Thomas Henry.
Catalogue 4 to No. 125.
Correspondence No., 308.
Discount 33⅓ per cent. and 2½ per cent. month.

Inquiries for special machines or complete contracts are handed to the chief draughtsman, who, instructed by the manager, prepares whatever drawings are necessary, and from these makes up the list of Quantities (Form No. 5). On this list, in addition to raw material, there are given the quantities of articles which may be purchased ready finished, such as lubricators, bolts and nuts, and other parts which it pays better to buy than to make.

THE FILING OF CATALOGUES.

Generally speaking, the prices of these may be taken from catalogues, so that a well-kept system of filing is very desirable. Catalogues as a rule are not well kept, the usual thing being to pile them on a shelf or stow them away in a drawer.

The system in use by the writer, and which he has also introduced recently in a large engineering works in the north, enables any catalogue to be found without any vexatious delay. The catalogues are kept in drawer boxes in which three sizes of drawer are used, one to take catalogues up to octavo, the second to take catalogues from octavo up to quarto, and the third to take sizes above quarto. Three books are kept, one for each size, in which the catalogues are entered and consecutive numbers given to them as they are received. To each catalogue is gummed a label (Form No. 78) on which are entered the particulars, which are also entered on two sets of cards, one under the names of the firms and the other under the subject matter.

INQUIRY.
Form No. 27.
W. Jones & Co., Ltd.
London, E.C. . . . . .19. . . .
M. . . . .
. . . .

Dear Sirs,
Please quote us your lowest price. . . . . on this form, which is written and printed in copying ink, for goods as below, packed and delivered. . . . . .stating the earliest time in which you can guarantee delivery.

Quantity.	Description.	Rate.	£		d.

Terms. . . . .
Packing. . . . .
Carriage. . . . .
Delivery within. . . . . .from date of order.
Signed. . . . .

Examples A and B show the entries on two cards.

PREPARATION OF ESTIMATES.

Where special quotations have to be asked for, an Inquiry Form (No. 27) is sent out. These forms are filled up and returned by firms tendering, and are from time to time bound into books. The forms are numbered and a card index is kept of them the same as for catalogues.

Having ascertained prices for all the materials given on the list of quantities, the estimate clerk then enters up the material column of Form No. 9, adding a percentage to cover unbooked material. For the labour, the draughtsman prepares a list similar to Form No. 5, but with the columns headed with the different classes of labour and their rates of wages. This list, together with the drawings, goes to the different foremen, who fill in their estimates of the number of hours the different parts will take. Before going back to the estimate clerk these lists should be passed by the works manager, who may see fit to modify the foreman's figures. The estimate clerk then fills in the labour column of Form No. 9 and adds the percentage necessary to cover standing charges. Costs of packing, railway charges, dock charges (if any) are then added, and the estimate is totalled.

The manager or principals then decide what price shall be quoted, and the Tender Form (No. 10) is filled up, together with the necessary specification and drawings.

ESTIMATE.
Form No. 9.
Date. . . . .
Tender No. . . . .
To. . . . .
For . . . .

Quantity.	Description.	Weight.			Rate.	Labour.			Material.			Charge.		
		Cwt.	qrs.	lbs.		£	s.	d.	£	s.	d.	£	s.	d.

LOCOMOTIVE ENGINEERING NOTES.

Liquid-fuel-burning Locomotives.

It is interesting to learn, upon what seems to be good authority, that Mr. R. J. Billinton, the locomotive superintendent of the London, Brighton and South Coast Railway, is about to try the experiment of burning liquid-fuel on some of the engines employed on that line. The system to be used is that invented by Mr. J. Holden, locomotive superintendent of the Great Eastern Railway. It has now been employed for many years on that railway, and has given results which must be characterised as entirely satisfactory. The use of liquid-fuel in locomotives is, of course, no novelty, having long been practised both in Russia and in America, where mineral oil is abundant and cheap. Mr. Holden's method, however, differs in some important respects from those hitherto employed in those countries where there is no uncertainty as to the permanence of ample supplies of the liquid-fuel. When Mr. Holden started the liquid-fuel movement in this country his object was simply to get rid of troublesome refuse, chiefly gas-tar. In the absence of any definite knowledge as to the amount of fuel that would be economically available, the engines, while able to burn liquid-fuel, had also to be fitted for coal consumption should the other combustible not be accessible. This principle has been adhered to in the case of all the liquid-fuel-burning locomotives of the Great Eastern Railway. Thus, should the liquid-fuel supplies at any time give out or become too costly, recourse can at once be had to coal without any alterations in the engines.

Method of Working.

In ordinary working the Holden engines burn liquid-fuel in association with solid combustibles, and not instead of them. The gas-tar or petroleum refuse is stored in tanks on the tender, and is sprayed into the firebox by means of roses on two pipes, through which the material is driven by a jet of steam, air being also admitted through an annular orifice in each rose. The hydro-carbon spray enters the firebox above a low coal fire in which there are numerous lumps of incandescent chalk. The spray is ignited, and while the engine is at work the firebox is filled with a clear, clean, pure white flame of great heating power, which the driver can regulate to greater or less intensity by adjusting two small thumbscrews. Thus the steam can be kept steadily at its most advantageous point, just below blowing-off mark during the whole length of a long non-stopping run, such as that from Liverpool Street to North Walsham—a distance of 131 miles, run at an average speed of about 50 miles an hour, and an actual working average of about 55. The convenience, cleanliness, and general advantageousness of the plan are indisputable.

Why not generally adopted?

It may fairly be asked: Why, if this plan be really so advantageous, has it not long ago been adopted by all the other railways? The answer is very simple. To use liquid-fuel engines, there must be ample supplies of liquid-fuel. Hitherto these have been wanting. The Great Eastern Railway practically absorbed all that could be obtained at remunerative rates. The locomotive superintendent of one of the leading Scottish lines wished to try the plan, but deemed it prudent first to ascertain whether, if he constructed the engines, he could get the fuel for them to burn. Finding, on enquiry, that the Great Eastern had secured all the cheap liquid-fuel available as far north as Glasgow itself, he reluctantly abandoned the idea. Lately, however, fresh sources of supply having been discovered, several railways have begun to use liquid-fuel, and the experiment will be tried on the London, Brighton and South Coast, as well as on the South Eastern and Chatham, and on the Metropolitan. Of its success there can be no doubt at all. Absolute proof has been afforded that Mr. Holden's system is equal to all requirements if adequately managed. Therefore, should it fail in any other case, the fault will be attributable, not to the system, but to its local working. However, no such failure need be anticipated, and the increasing use of liquid-fuel will do much to obviate the nuisance caused by railway smoke and sparks.

Compound Locomotives.

Another valuable improvement that of compounding, for locomotives, has recently made a fresh step forward in England. For many months rumour was busy with a report to the effect that at Derby—that railway "home of mystery"—a new type of compound locomotive had been designed by Mr. S. W. Johnson, the able locomotive superintendent of the Midland Railway, and that two pioneer engines of this class had been built. This report proves to be correct, and Nos. 2631 and 2632 have not only left the Derby shops, but have actively begun work, one taking daily the 10.5 a.m. train from Leeds and the other the 3.55 p.m. from Carlisle. The two engines are practically identical, save that one has plain copper tubes giving 1,598 square feet of tube heating-surface, while the other has the Serve or ribbed tubes, which give 1,720 square feet of surface. Each has 150 square feet of heating surface in the firebox, 26 square feet of grate area, and works at a boiler pressure of 195 lbs. of steam per square inch. Mr. Johnson appears to have adopted in a large measure the same arrangement of cylinders, etc., as that of No. 1619 on the North-Eastern Railway, excepting that the piston stroke is 26 in., both with the high-pressure and the low-pressure cylinders. There is only one high-pressure cylinder, which is placed inside the frames and drives the leading coupled axle by a single-throw crank. There are two low-pressure cylinders, each 21 in. in diameter, placed outside. They drive the same pair of wheels. By a special arrangement of the valves it is provided that although the steam pressure in the boiler may be 195 lbs. per square foot, the pistons shall never be forced to bear a severer strain than that which would ordinarily be experienced at a pressure of 170 lbs. in the boiler, which is that employed in many Midland engines. The pressure in the low-pressure cylinders is ordinarily 40 lbs. to 60 lbs., but this can be reinforced in case of need by the admission of auxiliary steam from the boiler through a special valve. Stephenson's link-motion is used to work the valves, and the reversing gear can be applied at will either to high-pressure or low-pressure cylinders separately, or to both together with the same handle. Special devices are employed to minimise back pressure.

Dimensions of New Midland Engines.

The leading dimensions of the new Midland compound engines are: Diameter of driving and trailing wheels coupled, 7 ft.; bogie wheels, 3 ft. 6 in.; high-pressure cylinder (1), 19 in. by 26 in.; low-pressure cylinders (2), 21 in. by 26 in.; total heating surface (plain tubes), 1,598 square feet (Serve tubes), 1,720 square feet; diameter of boiler barrel (inside), 4 ft. 8 in.; length of boiler 11 ft. 7 in.; height of boiler-centre above rails, 8 ft. 6 in.; grate area, 26 square feet; steam pressure, 195 lbs. Weight of engine in working order: On bogie wheels, 20½ tons; on driving wheels, 19½ tons; on trailing wheels, 19½ tons; total, 59½ tons. Tender (on two four-wheel bogies) loaded, 52½ tons; total of engine and tender, 112 tons. The new engines appear to be working very well and to be giving good results. It will be observed that Mr. Johnson, in his new three-cylinder compounds, exactly reverses Mr.

Webb's three-cylinder practice, as did Mr. Worsdell with No. 1619 on the North-Eastern Railway. That is to say, whereas Mr. Webb has two high-pressure cylinders outside and one low-pressure cylinder inside, Mr. Johnson and Mr. Worsdell have one high-pressure cylinder inside and two low-pressure cylinders outside. Experience alone can decide which of the two plans is preferable.

Two, three, or four-cylinder Compounds.

It will also be interesting to note the comparative working of this new class of three-cylinder compounds as against the performance of the four-cylinder types on the one hand, and the two-cylinder class on the other. With such able and eminent locomotive engineers as Messrs. du Bousquet, de Glehn, Mallet, Görlsdorff, von Borries, Webb, Worsdell, Vauclain, and now Mr. Johnson, all testing the compound system as applied to locomotives, some definite results must surely be reached at no very distant date. The point is a vital one in locomotive practice, and it should be settled definitely whether or not compound locomotives are advantageous on the score of economy and efficiency as compared with non-compound engines. If so, it remains to be proved which method is preferable—the two-cylinder, three-cylinder, or four-cylinder and of the several variants of these, which is the best. Experiments have been going on for very nearly twenty years in this country alone, and it is surely time that the question was solved decisively once and for all, as it has been in the case of steamships.

Another New Nord Tank Engine.

A large number of M. du Bousquet's new express tank engines for fast suburban traffic are now at work on the Chemin de Fer du Nord, and are doing extremely well. They run on twelve wheels, the two middle pairs being coupled to have both leading and trailing four-wheel bogies. Their boilers are unusually high-pitched for tank engines. They have 5 ft. 5 in. coupled wheels, outside cylinders 17 in. by 23½ in., and 1,395 square feet of heating surface. The type is a remarkably good and efficient one for that class of service.

"Atlantic" type Engine for Orleans Railway.

Some large express engines of the "Atlantic" type and on M. de Glehn's four-cylinder compound principle, have been designed by M. Solacroup, the eminent chief mechanical engineer of the Paris-Orleans Railway, for the heavy express service of that line, and are now in course of construction. It is understood that they will be very similar to those referred to above in the case of the Chemin de Fer du Nord.

MODERN PRACTICE IN MILLING AND AMALGAMATING.

BY

EDGAR SMART, A.M.I.C.E.

In the preceding Article the author discussed separately the various conditions necessary to secure a maximum of efficiency in stamping mills. The present Article deals more particularly with amalgamating, and institutes an interesting comparison between the respective methods.

II.

AMALGAMATION.

GOLD ores have been generally divided in a vague sort of way into two classes, termed free milling and refractory ores respectively. That is to say, when a fair proportion of the value contained in any auriferous material can be readily amalgamated with quicksilver, it is termed a free milling ore. At one time it was considered that gold which could not be recovered in this way was in chemical combination with other elements, such as sulphur. Nowadays it is generally admitted that, with the exception of tellurides of gold, practically all known ores contain their gold in a free or uncombined state, and that amalgamation difficulties are due to one or the other of the following causes :—

1. The sickening of the quicksilver by certain mineral constituents present in the gangue, antimony sulphide being the most troublesome in this respect, although good work is done in Australia on ores containing up to 1 per cent. of this mineral.

2. The gold existing as a fine deposit upon and in the crystals of iron pyrites, so that it cannot be retained by the quicksilver, but is carried away with the particles of pyrites.

3. The particles of gold being so fine that they remain mixed with the pulp, and do not come in contact with the quicksilver.

In the first case, only a part of the gold can be caught by prolonged pounding in the mortar box, or by some equivalent method, and this is accompanied by a large loss of quicksilver and amalgam. In the second case, amalgamation in grinding pans is effective, but not economical, owing to the large cost for power and the loss of mercury, which latter is not so great, however, as in the first case. In the third case, amalgamation is quite unsuitable, and in modern practice no attempt is made in the last two cases to catch the gold in the mill, because, as already mentioned, more successful methods are now available, and experience has shown that the percentage of gold recoverable from any ore by the best amalgamation methods depends almost entirely upon the relative amounts of coarse and fine gold present, and upon the physical conditions above mentioned.

Any comparisons, therefore, made upon the basis of percentage extraction, between one man's work and that of another, or between one method and another, may be utterly misleading, unless the same kind of material is being dealt with in both cases. Thus, for instance, on the Bendigo goldfields, where the treatment process consists almost universally of crushing and amalgamating, followed only by concentration on large canvas tables, the tailings from this simple treatment average about 1½ dwts. to the ton over the whole district, the maximum value for any large quantity being about 2 dwts. According to the official returns the average recovery on over 2,000,000 tons was

8 dwts. of bullion, equal probably to 7½ dwts. of fine gold. On the Rand goldfields, at the time when only amalgamation and concentration were used for gold recovery, the tailings from ore of a similar grade would average at least 2½ dwts. per ton, but it would certainly be absurd to infer from this difference of results that the Rand millmen at that time were inferior to their brethren in Bendigo.

The next example illustrates the fact that with a given ore, the percentage of recovery by amalgamation is independent of the value. In Gippsland, Victoria, in a mill catching 1 oz. of gold per ton the tailings contained 2 dwts. In another mill, working ore from the same line of reef, the recovery was 2 ozs., and the loss in the tailings was 4 dwts., so that the percentage was the same in both cases.

It must not be supposed that the moral of all this is that skill and care are unnecessary in the amalgamation process; on the contrary, they are essential to success. But it is necessary to get rid of the idea, so prevalent in some parts of the world, that a loss of gold in tailings is a certain proof that the battery work is inefficient. If this were merely a personal matter between mine owners and employes it would not be necessary to elaborate the point in a technical consideration of the subject; but it is a matter which in some cases causes the total loss of gold which might be recovered by other means. In fact, where this opinion prevails, the millman who (from his point of view) is cursed with rich tailings dare not face the fact and recommend the application of cyanide or other additional treatment; but he endeavours by any means possible to make it appear that his tailings are poor. One instance will forcibly illustrate the fact that this feeling does really exist. On one occasion a sampler was sent to take samples of tailings pulp below the canvas tables of a certain mill, say in Australasia, with a view to purchasing the current tailings. The manager who represented the sellers had all his canvas tables carefully cleaned up before the samples were taken, so that they should be working at their maximum efficiency, and that therefore, the tailings samples should be as poor as possible. Naturally, the representative of the buyers made no objection, but the shareholders in the company might have done so very reasonably.

There is no doubt that the recognition of the natural limitations of the amalgamation process is not only necessary for the determination of the best treatment of any given ore, but it also conduces to the proper working of the mill. In Johannesburg it cleared the way for the improvements which have so largely increased the output of the mills, without decreasing their efficiency in catching gold.

THE USE OF MERCURY.

The whole process depends on the one fundamental fact that clean gold readily amalgamates with clean mercury when the two are brought into actual contact. It is not surprising, therefore, that many attempts have been made to achieve this result by means of baffle plates, riffles, shaking tables, and the like, the leading idea in all such apparatus being to *disturb* the flow of pulp as much as possible, and to produce currents and eddies which should dash the particles of gold against amalgamated surfaces. Probably, every beginner in the art has been the proud possessor of some such idea at one time or another; and only those are truly happy who have not spent their own money in demonstrating its inutility in practical work.

The other point of view is to disturb the pulp as little as possible, and to allow it to flow so evenly and steadily that each particle of gold can gradually settle down through the pulp till it finally comes naturally and quietly into contact with the amalgamated plate beneath it, and is thereby caught. Of course, as the pulp is delivered from the mortar box in the form of a series of splashes superimposed upon a regular flow of water, an absolutely even flow cannot be expected, but, at all events, by avoiding artificial means for disturbing the flow, better results can be obtained than otherwise. The credit of introducing on the Rand the long unbroken surfaces of amalgamated plate instead of several short lengths with drops or riffles between them is due to the well-known mining engineer, Hennen Jennings, who demonstrated the advantage of the unbroken surface by means of simultaneous experiments on the two systems. The usual arrangement now is a lip plate, which projects a few inches immediately below the screen frame, and delivers the pulp on to a splash plate, which is inclined downwards towards the screen, and projects under the lip plate. From the splash plate the pulp is delivered to the head of the table, and thence flows uninterruptedly along until it reaches the mercury well at the foot of the table.

THE FUNCTION OF COPPER PLATES.

It is obvious that if the particles were brought into contact with the clean surface of a pool of liquid quicksilver they would be amalgamated, but the amalgam, being heavier than the mercury, would fall to the bottom, and a surface of mercury only would be available for catching more gold, while experience has shown that a surface of gold amalgam keeps cleaner and in better condition than the quicksilver alone. Therefore, by using a mercury film on a metal plate, the surface soon becomes covered with a layer of gold amalgam. There are other self-evident objections to the use of liquid mercury —its cost, owing to the quantity required to form a large continuous surface, the loss by attrition caused by particles of ore, and the impossibility of having an inclined surface. It is only necessary to mention these well-known facts, because they point to the true functions of the copper plate—namely, that it allows of the formation of an extended surface with a small quantity of quicksilver, that it holds the latter in place and keeps the amalgam on the surface, where it is required to catch more gold. In fact, it has the same duty as the glass in a photographic plate; it serves as a support for the active film upon it.

A man standing on the bank of a river holding on to a tree with one hand and reaching out with the other for floating sticks illustrates the position of the quicksilver. So long as both hands perform their function the work is satisfactory; if either fails, then either the sticks are lost or sticks and man together. Just in the same way the quicksilver is required to seize the particles of gold and to hold on to the plate at the same time. The one thing necessary to enable it to do both satisfactorily is cleanliness.

In the first place, the copper plate must be absolutely clean before being amalgamated, so that the film of quicksilver shall cover the whole of its surface. This cleaning is usually done by scouring with sand, and afterwards with wood ashes, or with caustic alkalies, to get rid of the two most potent enemies of the quicksilver—namely, grease and films of oxide on the metal. Perhaps the latest method of amalgamating the plate after it has been cleaned is to rub it over with a solution of potassium cyanide in which quicksilver has been dissolved. As it is rubbed with this solution its surface becomes gradually whitened by a very thin deposit of the mercury, after which either mercury or amalgam of gold or silver will adhere to the surface when rubbed on. But this is only the first stage of preparation, for as soon as the plate is in use, the soluble sulphates and other bodies in the ore form coloured patches, generally greenish, on the copper, and these patches will not retain the film of quicksilver. This is the first matter that needs the attention of the amalgamator, who must constantly clean off these greenish films and rub in amalgam until the whole plate gets into good condition. It is often assumed that this improvement is entirely due to the gradual increase of gold amalgam on the surface, and this is no doubt true to a large extent, as evidenced by the fact that when crushing rich ore the plates get into order more quickly than with poor stuff. But it is also probable that in the first place only the very outer surface of the copper becomes coated with quicksilver, and that the coloured films, caused by oxidation or other similar action, begin in the pores of the metal and gradually extend under the mercury, which can then no longer hold on to the plate. As the amalgamation of the copper penetrates into the thickness of the plate and the surface pores at least are amalgamated, it becomes increasingly difficult for the battery water to come into actual contact with metallic copper, and consequently no objectionable films can be formed. With care and patience new plates can be got into good condition in a couple of weeks. If might be well asked whether any great improvements have been made in recent years, or indeed whether any advance is necessary or possible in conducting operations so simple as those just described. The chief gain during the last few years has been the application of plain common sense to the art of amalgamation and the consequent disappearance of the professional "plate-setter," who like a Kaffir witch-finder was surrounded by a halo of mystery, and was supposed to carry a heavy burden of carefully concealed special knowledge, enabling him, by proper nostrums, possibly mixed with spells and incantations, to induce the plates to perform their office.

SILVER-PLATED COPPER.

The use of electro-silvered copper plates for batteries has been strongly advocated by some authorities and as strongly condemned by others. As usual in such cases the truth seems to be situated in the equatorial regions half-way between the two opposite poles of personal opinion. It is a reasonable supposition, in consequence of the wide range of variations in the constituents of ores, that the battery water in some instances may tarnish copper more readily than silver, and that in other cases it may have exactly the opposite effect.

This is at all events a possible explanation of some of the differences of opinion which exist on this matter. The silvered plate certainly has the advantage that it can be more easily coated with the mercury in the first place, and that when this operation has been performed, the whole surface is then covered with silver amalgam, which is less easily tarnished than a plain mercury surface. Therefore it may safely be said that generally in places where inferior labour has to be employed, the use of electro-silvered plates will prevent loss of gold during the first few weeks of the operations, and that only in some cases, as suggested above, could they possibly do any harm. But when the plate is well amalgamated all over, when after a few months' work this amalgamation has penetrated into the plate and a quantity of gold amalgam has been retained upon it, and when much of the silver must have been removed with the gold in the periodical cleaning up, it is scarcely reasonable to suppose that the original plating can have any beneficial effect.

The latest advocate for silver-plated copper, Mr. Edward Halse, makes out an excellent case for it by showing that at a mine in Columbia a considerably larger percentage of gold was caught on the plates, and a correspondingly smaller percentage on the blankets when silvered plates were substituted for plain copper ones,* and that this increase was a permanent one. But he then says "it should be mentioned here that much more mercury was used with the plain copper than with the silvered plates, which accounts for a good deal of the amalgam found in the mercury traps and on the blankets in the former." Now this appears to be the most important sentence in the whole paper, for as the remaining conditions were fairly constant, then if the right quantity of mercury was used with the silvered plate it follows that an excessive amount must have been used previously with the plain copper, with the natural result indicated. In fact this one sentence explains the whole of the results in such a simple and convincing manner, that the case for the silvered plates so ably advanced seems to be thereby put out of court. It is quite in accordance with experience that excess of mercury will carry amalgam off the plates on to the blankets below them, while it is hard to understand how a single addition of one ounce of silver per square foot of plate can have a greater permanent effect than the many ounces of gold caught from time to time during the continued working of either kind of plate.

Mr. G. E. Collings, on the same occasion, gave results of two sets of comparative tests which showed a greater return in *amalgam* in each case from silvered copper than from plain copper, but the yield in *melted gold* was in one set greater and in the other set less from the silvered plates. In other experiments between new and old silvered plates the results were equal. So the conclusion from the evidence seems to be that while silver-plating may be of advantage at first, it makes no practical difference after a few months' operations.

INSIDE AMALGAMATION.

This is another question upon which widely different views are held, principally because each man favours the practice which gives the best result with the kind of ore with which he is most familiar. When the gold is nuggety in character it is sure to stay in the boxes, whether mercury be added or not, but the addition of the mercury rather facilitates the collection of the gold when the mortar boxes are cleaned out, and it is therefore generally used with very coarse gold, and sometimes inside plates are used.

When the gold is fine enough to pass the screens as quickly as it is liberated from the gangue it is a matter of less importance as to whether inside plates are used. The main argument in favour of them is that it is wise to catch the gold as soon as possible, and that back and front plates receive nearly all that part of the splash which does not strike the screen, so that every particle of gold is amalgamated at the earliest possible opportunity. There is one necessary precaution which is not lost sight of at the present day, namely, that the mercury necessary for the inside plates must be added in very small quantities at frequent intervals, in order that the outside plates shall not at any time receive an excess from the mortar boxes.

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* Proceedings. Inst. Mining and Metallurgy. Vol. IX., p. 155, *et seq.*

With very fine gold in clean ores good work is done both with and without amalgamation in the mortar boxes.

QUANTITY OF QUICKSILVER.

The amount of quicksilver which must be supplied to the plates either directly or through the boxes depends not only upon the quantity of gold, but also upon the size of the particles which have to be caught. The amalgam on the plates cannot be expected to carry more gold than the proportion found in the squeezed amalgam as prepared for retorting; in fact, it must necessarily carry less. This squeezed amalgam contains about 25 per cent. of gold when very fine, and up to, say, 70 per cent. in the case of very coarse gold. These figures then will give the absolute minimum quantity of mercury which must be added per ounce of gold caught. That is to say, with the finest gold at least 3 ozs. of quicksilver should be added to the plates for each ounce of gold caught upon them, while for coarse gold one-sixth of this would be the minimum quantity. Of course, in practice more than this is added, and with inside plates much more, because part of it settles down and collects in the boxes. The safest guide is the condition of the plates. When too much is given it can be seen trickling slowly in little streams along the plate, and, although most of this excess is caught in the mercury trap at the foot of the table, some of it is liable to be floured and lost. And loss of quicksilver from the plates means also loss of fine gold. If, on the other hand, too little is given, the gold amalgam on the plates becomes dry and friable, and is liable to be carried away by the attrition of the grains of sand. Amalgam in fit condition to catch gold should appear *moist* and *granular*, but not wet.

WATER SUPPLY.

The water used in the battery may be considered in the first place as the vehicle by means of which the crushed ore is transferred from the mortar box and carried over the plates; and, secondly, as the medium through which the gold can settle down on to the plates while the gangue particles having less specific gravity are carried forward by the current. As regards the first function, the quantity required will necessarily vary with the nature of the ore, but in any given case the effect of altering the quantity can be ascertained by a series of grading tests on the pulp produced.

The following example of such tests is taken from a paper read by Mr. John McConnell, of New Zealand, before the Institution of Mining and Metallurgy.* It is particularly interesting as showing what occurs when very fine screens and very limited quantities of water are used, as well as illustrating the method of testing.

1. Crushing with 2 tons of water per ton of ore :—

Sand retained on	60-mesh screen	3 p.c.
,, ,,	90- ,,	21 ,,
,, passed through	90- ,,	76 ,,

2. Crushing with 4 tons of water per ton of ore :—

Sand retained on	60-mesh screen	13·5 p.c.
,, ,,	90- ,,	20·5 ,,
,, passed through	90- ,,	66·0 ,,

As these tests were made for a special object, no results are given with larger quantities of water, but they show that the increase of water from 2 tons to 4 tons reduces the amount of very fine stuff by 10 per cent. The next example shows the result of crushing Rand ore with about 9 tons of water per ton of ore. As the material is different and the battery screen was coarser, it cannot be rigidly compared with the figures given above. The test was made by Mr. A. F. Crosse, of Johannesburg,† and may be taken as typical of the results obtained there.

Sand retained on	30-mesh screen	6·25 p.c.
,, ,,	60- ,,	29·30 ,,
,, ,,	90- ,,	30·00 ,,
,, ,,	120- ,,	9·25 ,,
,, passed through	120- ,,	25·30 ,,

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* Vol. VII., p. 26, *et seq*.

† Proceedings of Chemical and Metallurgical Society of South Africa. vol. i., p. 325.

Returning to the second function of the water, namely, as a medium for the settlement of the gold, it is clear that the slower the velocity of the stream the more rapidly can the settlement take place; but, on the other hand, a sufficient state of flow must be maintained to just carry off the heaviest particles of the gangue, and it is this limiting velocity which is aimed at in practice. The required velocity is quite a separate question from the quantity of water, and it is attained by the inclination given to the tables. Thus, with a gangue of clean quartz, finely crushed, a slope of 1 in. per foot is sufficient. With iron pyrites present, and with 700-mesh screens, 1½ in. per foot is used; and with ores containing heavy minerals, such as galena, 2½ in. per foot is required. In most cases a few particles of mineral or of black sand may be seen clinging to the surface of the amalgam. Having determined the velocity, the quantity of water supplied must then be sufficient to keep the plates well covered; and where the quantity passing through the boxes is not enough for this purpose, it is usual to provide an extra supply at the head of the plates outside the boxes. An excess of water does not cause a proportional increase in the rate of flow, and up to a certain point the settlement of the gold is probably assisted by the dilution of the pulp. Up to the present time the tendency has been towards liberality in water supply; but it is possible that the New Zealand practice of crushing with limited quantities of cyanide solution may be followed in other countries where the gold is in a similarly fine condition.

SAVING WATER.

There are many places where the quantity of water available is strictly limited, and where every care has consequently to be taken to preserve it for use over and over again. The statement that a mill requires 6¼ gallons per stamp per minute does not look very large; but when the total quantity used in a year is reckoned up and compared with the rainfall, the result is somewhat startling. As an example, take a 100-stamp mill, crushing 500 tons of ore with 4,500 tons of water daily = 144,000 cubic feet. At 360 days per annum, this is 51,840,000 cubic feet, which is equal to one inch of rainfall over 22·3 square miles of country.

The most obvious means for saving water is the provision of settling dams of large capacity for the clarification of the water, these being preferably situated below the mill, so that clear water only has to be passed through the pumps.

Settling boxes, with pointed or flat bottoms, and also small settling dams, shovelled empty at intervals, have been often used for this purpose with some success. But in recent years on the Rand goldfields, the methods primarily designed for the precipitation of the battery, sands and slimes for immediate further treatment have led to the development of an excellent system of saving and clarifying water, so that it can at once be returned to the mill. Briefly described, this includes first, the elimination of coarse sand in spitzlutten; secondly, the separation of fine sand in overflow tanks; thirdly, the addition of quicklime; and fourthly, the settlement of the slime in a large spitzkasten so completely that the water is at once fit to use again. At the Matterhorn Mine, in America, a similiar system, on a small scale and without the use of lime, was successfully employed,* and 75 per cent. to 80 per cent. of the battery was returned for re-use.

The following sizes are found suitable for the spitzkasten with Johannesburg ore when lime is used. Width 0·55 foot for each cubic foot of pulp delivered per minute, and the length from two-thirds to three-quarters of the width. In order to avoid an excessive depth the spitzkasten are divided into a number of divisions, each being about 5 ft. square, and each having a separate pointed bottom and outlet. At the Matterhorn Mine above mentioned, a spitzkasten, 6 ft. wide and 10 ft. long, was used for each five stamps, the allowance being 3·33 ft. of width for each cubit foot of pulp per minute; that is, six times the width allowed in Johannesburg. The difference is apparently due to two causes: First, the absence of lime in the Matterhorn case, and, secondly, the extreme fineness of the pulp, as evidenced by the fact that 79 per cent. of the whole product passed through a 100-mesh screen. The two cases may be taken as representing the extreme limits of practice in either direction in connection with the settlement of slime.

MILLING v. AMALGAMATING.

Having now considered separately the most important points connected with milling and amalgamation, a few words may be said on the question raised in the early part of this article as to whether a high stamp duty necessarily involves a loss of gold which might otherwise be caught on the plates. Where the gold is coarse it settles so readily in the boxes and on the plates that it cannot be imagined for a moment that any rate of crushing practically possible could affect the percentage recovered by amalgamation. So far as the plates are concerned, an increase of output must result in one of two things—either the pulp will carry more solid matter per unit of volume if the water supply remains constant, or there will be a greater depth of pulp on the plates if the water supply is increased. In either case it is possible to suppose that a limit may be reached in time which will interfere with the rapid settlement of very fine gold on the surface of the plates; but up to the highest stamp duty yet attained this effect is likely to be negligible. Owing to variations in ores and in other conditions, it is difficult to get figures which can be compared with strict fairness, but the following tables, compiled from the annual reports of the two Johannesburg companies, bear out the above statement:—

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* "Engineering and Mining Journal," May 5th, 1900. By A. W. Warwick.

TABLE III.—RETURNS FROM CROWN REEF GOLD MINING COMPANY.

Year.	Tonnage.	Tons per stamp per 24 hours.	Percentage of Ore value recovered in Mill.
1895-6	209,442	5·116	52·901
1896-7	199,898	4·795	50·010
1897-8	185,179	4·603	57·806
1898-9	202,456	4·908	56·420
1901	12,269	5·446	—

TABLE IV.—RETURNS FROM SIMMER AND JACK PROPRIETARY MINES, LTD.

Year.	Tonnage.	Tons per stamp per 24 hours.	Gold caught in Mill. Dwts. per ton.
1897	123,325	4·37	5·83
"	35,740	4·80	0·25
1898	79,800	4·47	5·08
"	103,440	5·02	6·13
"	115,090	5·27	6·35
"	123,540	5·38	6·57
1899	129,430	5·37	6·73
"	133,710	5·47	6·35
"	128,639	5·41	5·01

It will be observed that neither table shows any indication of loss of gold as a consequence of increased stamp duty.

A RECENT RAND MILL.

The mill of the Lancaster West G. M. Company commenced crushing only a few months before the war, and will serve as an example of the very latest Johannesburg practice. The following particulars are obtained from the company's annual report:—

The ore breakers are situated at the back of the mill below the ground level, so that the ore can be conveniently delivered to them in trucks from bins at the headgear. The broken ore passes into bins below the breakers, and thence is carried to the top of the mill by a Reedy elevator. There are two crushers of the Blake-Marsden type, 24 in. by 14 in. The mill is provided with exceptionally large ore bins, their capacity being equal to four and a half days' crushing. There are forty stamps, weighing 1,250 lbs. each. The engine, supplied by the Erste Brunner Maechinen Fabrik, is a compound tandem with high-pressure cylinder of 18¾ in. diameter, low-pressure cylinder, 30 in. diameter, and with a 3 ft. stroke. It is estimated to drive 100 stamps if necessary. The rock breakers are driven by a similar engine, whose dimensions are 15¾ in., 25⅝ in., and 31½ in., respectively. Surface condensers are used, and water-tube boilers supply the steam.

This mill started towards the end of May, 1899, and was stopped in the middle of October of the same year, on account of the then impending war, and during this short period it crushed 31,730 tons of ore in 123·3 days, actual running time, which works out at 6·43 tons per stamp per day.

COST OF MILLING.

A great deal might be said on this section of the subject, but the following miscellaneous collection of official figures will sufficiently illustrate the great variation of working cost, caused by local conditions to some extent, but which of course are largely due to the scale upon which operations are conducted. The examples have been taken almost at random from the enormous amount of such useful information to be found in the reports of Chambers of Mines and Mining Companies. Where possible, the tonnage crushed is inserted, as well as the cost, together with other information which affects the cost :—

1. Guests Gold Mine, Mt. Morgan, W.A. June, 1900:—

Crushed 695 tons for 343 ozs. bullion.
Cost of milling, including water supply, 14s. per ton.

2. Lady Loch, W.A. June, 1900:—
Crushed 750 tons for 602 ozs. bullion.
Cost of milling, 7s. 8d. per ton.

3. Hill End, W.A. May, 1900:—
Crushed 770 tons for 642 ozs. bullion.
Cost of milling, 9s. 4d. per ton.

4. Vale of Coolgardie. June, 1900 :—
Crushed 1,040 tons for 601 ozs. bullion.
Per stamp per 24 hours, 3·6 tons.
Cost of milling, 8s. 10d.

5. Norseman Gold Mines, W.A. June, 1900:—

Crushed 2,244 tons for 785 ozs. bullion.
Per stamp per 24 hours, 3·35 tons.
Cost of milling, 6s. 3d.

6. Sons of Gwalia, Leonora district, W.A. Average of nine months in 1900, during which 33,812 tons were crushed :—

		s.	d.
Ore transport	...	0	10·68
Milling ...	...	5	0·21
Maintenance	...	0	5·90
General charges	...	0	8·23
Total	...	7	1·02

7. Wentworth Mine, New South Wales. Year 1898, during which 1,898 tons were crushed :—

		s.	d.
Labour ..	...	0	10·2
Fuel	..	1	1·6
Stores	...	0	2·0
Maintenance ...	...	1	0·5
Management ...	...	0	3·7
Total	...	3	6

8. Lancaster West Mine, Johannesburg, with mill described above :—

		s.	d.
Sorting, tramming and breaking		1	2·19
Milling	...	2	3·86
Total	...	3	6·05

9. Robinson Mine, Johannesburg, December, 1901 (during the war):—
Crushed, 8,036 tons.
Milling, including maintenance, 2s. 11·12d.
Concentrating, including maintenance, 5·57d.

10. Crown Reef Mine, Johannesburg, 1895 to 1899 :—

Year	1895-6.	1896-7.	1897-8	1898-9.
Tons crushed	209,442	199,898	185,179	202,456
	s. d.	s. d	s. d.	s. d.
Engine-room expenses	0 9·601	0 9·838	0 8·855	0 8·727
Mill-working cost	0 7·283	0 8·142	0 8·285	0 6·617
Pumping station...	0 4·308	0 4·552	0 6·912	0 5·988
Maintenance	0 8·710	0 8·117	0 9·562	0 10·646
Assay office	0 0·706	0 0·780	0 0·952	0 0·931
Electric light	0 0·722	0 0·714	0 0·720	0 0·894
Totals	2 7·330	2 8·130	2 11·288	2 9·806

The uniformity during so many years of the total costs in this last example, and also of the individual items, may be noted as an indication of the perfect control which can be maintained over an enormous expenditure by means of the detailed accounts and systematic analyses of costs which are characteristic of Rand mining. Owing to the exceptionally complete technical information published by the management of this company the analysis of the costs for 1898-9 can also be given in the following way :—

		s.	d.
European wages ...	...	0	8·914
Kaffir wages, including food		0	2·110
Materials and tools...	..	0	11·280
Fuel	...	0	7·356
Lighting	...	0	0·894
Workshops	...	0	3·252
Total, as above	...	2	9·806

Considering the high cost of all white labour and of materials in Johannesburg, and that the Kaffir labour has very little effect on the cost of the mill work, the above figures, which are fairly representative of the whole district, show how cheaply the work can be carried on under the beneficent combination of large tonnage and efficient management.

WORKSHOP PRACTICE

A RÉSUMÉ OF MACHINE TOOLS, CRANES, AND FOUNDRY MATTERS FOR THE MONTH.

A LATHE FOR 4-INCH BAR WORK.

A NEW lathe has been designed by Clark's Engineering and Machine Tool Company, Ltd., of Luton, for exceptionally heavy bar work. The hollow spindle is bored out to $4\frac{1}{8}$ in. diameter, and the lathe is capable of reducing a 4-in. bar to $1\frac{1}{2}$ in. diameter at one cut. One of similar design is made for 3-in. bars, and the firm is about to bring out one for dealing with 6 in. stock. Lathes of such capacity and power as these render much bar work less costly than machined forgings.

The general build of the lathe is English, modified by the hollow spindle and the unusually massive proportions. Besides heavy bar work it will do all that an ordinary sliding, surfacing, and screw cutting lathe is capable of performing. It is driven by a 4-in. belt, and is back geared, the gears being encased. The back shaft has three changes of speed for sliding and surfacing by differential gears, which are put into operation by a lever in front, below the headstock, and without stopping the machine. The common English type of saddle is employed, but it has two rests. The one in front carries four tools, and can be revolved to bring either tool into operation, and a stop is fitted for transverse adjustment. The other rest at the back of the cross slide carries cutting-off or forming tools. This can be removed, and a screwing die head put in its place for screwing the ends of pins, etc., up to $2\frac{1}{2}$ in. diameter.

The headstock caps are set at an angle with the base, so reducing the strain on the studs, and improving the adjustment sideways, instead of up and down only. A hinged bar support is seen at the rear, and a cupboard for tools under the head. Ordinary forged tools are used. The lead screw is protected by a long cap ; a waste oil tray lies below the bed ; the ribs of the loose poppet are cut away to clear the handle of the slide rest, and the change gears are massive, harmonising thus with the general design. Such a lathe as this should be an acquisition in those shops where there is not a sufficient volume of work for automatics or heavy turret lathes.

HIGH SPEED TOOL STEELS.

Unusual rivalry is being manifested in the production of high speed tool steels, following the Taylor-White, shown in operation at Vincennes in 1900, and several firms now offer such steels. A Manchester committee has made arrangements for the testing of samples of these, offered by eight local firms. Sir W. G. Armstrong, Whitworth, and Co. have brought out a steel of their own brand which they claim has beaten the Taylor-White by 25 per cent. in cutting speed, though the cutting was continued for more than twice the length of time. A tool has been run for forty-five minutes at 150 ft. per minute, with a $\frac{3}{16}$ in. cut, and $\frac{1}{16}$ in. traverse. A Sheffield firm has an air-hardened steel which has tooled a hard cast steel pump plunger at 80 ft. a minute, lasting for forty minutes without injury to the tool, in this case with a cut of $\frac{3}{8}$ and $\frac{3}{16}$ in. feed. Other severe tests have been given in which the tools have retained their edges. We shall hear more of these high speed steels. A result is that st lathes have to be manufactured to endure the higher stresses imposed by such severe cutting.

DRILLING EXTRAORDINARY.

The great interest which attaches to any reported increase in the amount of metal removed in a given time by cutting tools, illustrates the great importance of this subject in competitive production. The new machines and tools give an enormous output compared with the older ones. But the difference between some of the modern kinds and the older ones is not much less than that between these and hand labour. This fact has received illustration lately in two directions, the work of twist drills, and in the high speed steels, just instanced.

The Morse table of speeds for drills is generally accepted as the best standard for the use of up-to-date shops, and higher than the practice of the older shops. But the Bickford Drill and Tool Company have recently been exceeding these performances, employing feeds so coarse that the marvel seems that the drills have not been broken. The firm has, in several experiments, tested the drills to destruction; but in some instances the experiments were stopped by the slipping of the belt. The Morse table recommends for ¼-in. drills a feed of ·005 in. per revolution; for a ½ in. drill ·007 in. per revolution. The Bickford practice gives a feed of ·025 in. for drills from ¼ to ½-in. For ¾-in. drills the Morse feed is ·010 in. per revolution; the Bickford feed for ½-in. to 1-in. drills is ·035 in. per revolution, and these differences are paralleled in other sizes.

Tests made to destruction, on a ¼-in. drill, drilling in cast iron, showed that a rate of feed of ·047 per revolution was required to break the drill, and one of ·064 on a $\frac{5}{16}$-in. drill. A ⅜-in. drill could not be broken with a feed of ·064 in. per revolution, at 267 revolutions per minute. In one case a 1¼-in. drill working in machinery steel did not break until the feed was increased to ·1 in. per revolution. A feed on a $1\frac{9}{16}$-in. drill, also in steel, gave a chip measuring $\frac{9}{32}$ in. in thickness, at which the machine was pulled up. The drills used were ordinary commercial ones, and the Bickford Company attribute these results to the form of the arm of the machine, which is tubular, and therefore well designed to resist torsional stress.

This machine was one which was introduced last year. It is noteworthy, because cone pulleys are abandoned and a nest of gears substituted for effecting changes in speeds. One of the advantages of this design is, that such a machine can be driven electrically with a constant speed motor, which is preferred by many to the variable speed type. Another is, that when belt driven, the belt is not slowed down for heavy cutting, as is the case when cone pulleys are used. Then there is the rapidity with which changes can be effected. Sixteen spindle speeds are obtainable with the gear box, and back gears, arranged in geometrical progression from 16 to 256 revolutions per minute. These rapid changes and feeds enable the machine to turn out a large quantity of work. A sample of this is an iron plate 1 in. thick, in which 15 holes, ranging from ½ in. to 3½ in. were drilled within 27 minutes, which included changing of 15 drills, and speeds.

INSERTED VEES.

A curious recent American patent is for inserted vees in machine slides. The vees are of steel, and the idea is to delay their wear for an indefinite period. They are hardened and afterwards ground in place. The projecting vee is fitted by a tongue running longitudinally, the recessed vee fits in a recess which is very slightly beyond hemispherical in shape. The vees in American lathe beds are objectionable from the point of view of durability, hence the desirability of using insertion strips of hardened steel.

A NEW DISC GRINDER.

The disc grinders, in which emery cloth is cemented on steel discs, have come into favour very rapidly during the last three years. Several are now manufactured both in England and America. The latest design is that of Messrs. C. W. Burton, Griffiths and Co., of Ludgate Square, London, E.C., and it embodies a number of excellent practical features, making it a very high-class, fine precision machine. The two tables are carried on bars, which are adjustable vertically in guides in which they are clamped. Their mass is exactly counterbalanced by chains and weights. The guides have long bosses, which embrace a 3-in. steel shaft that passes through the base, near the front, and plumb beneath the locality where the grinding is done. The guides have a transverse movement to and fro along the shaft, fine adjustment being effected by a hand wheel and screw, a movable index and stop. The guides also swing upon the shaft, so that work can be surfaced across the wheels. The tables are each pivoted on a stout pin for vertical angles. They are locked square by a Morse taper pin. Horizonal angles are obtained by a gauge, set by a scale on the edge of the table and clamped. Tee slots are provided for holding work down.

The spindle—1¾ in. in diameter—is hardened and ground, and runs in long bearings of gun-metal, with a self-oiling ring. The emery cloth is cemented on the large discs, which are of annealed steel 20 in. in diameter. These are attached to the smaller bosses behind them, which are shrunk and keyed on the spindle ends. The discs are retained in place, each with a collar registered into the boss, and fastened with a left-hand screw on the spindle end. The cloth is cemented on the discs in a press, which is fitted at the back of the machine, instead of using a separate press stand, thus economising space. Ample protection is afforded to the bearings against access of grit, and the details of the machine are worked out very well.

FOUNDRY MATTERS.

A new brass melting furnace has been designed by Mr. W. Mayer, of Dumbarton, and is manufactured by Messrs. Hardie and Gordon, of Dumbarton. It belongs to the air furnace class, but possesses several original features, one being the form in plan, which is tapered from front to back, with an arrangement of regulating shutters, exceptionally deep fire bars, and a deep reservoir or well for the molten metal. The firing is done from the broad end of the furnace. Air is admitted on each side of the firing door, through sliding shutters, an air portway is formed at the bottom of the fire door, and another just above the fire bars, suitably proportioned to the grate area. Through another opening below, air is admitted above the fire bars. The latter are of great depth—a foot or more—hanging right down into the ash-pit. Air in passing up through these bars mixes with the air which is drawn in above the bars, and produces thorough combustion of the gases. The bridge is high, and the roof deeply arched. The well behind the bridge receives the molten metal, where there is less heat than at the throat, and less risk of volatilization. The sight hole and the tap hole and spout are at one side, or tapping may be arranged for both sides. The furnace is built generally as in other designs with cast iron plates, brick lined, and one end is supported on rollers to permit of longitudinal expansion by heat. It is portable.

The furnace burns hard coal, and is very economical, melting 1 cwt. of brass with an average consumption of ½ cwt. of coal. Three and a-half hundredweights is worked off in one heat, and six or more heats of that weight can be melted in a day, or twelve heats or more with lesser quantities. The average loss in melting gun-metal is 2 per cent., common brass 3 per cent., yellow brass 4 to 6 per cent. The brass is tapped into a ladle, as in the case of iron running from a cupola. Iron and other metals can be melted in small quantities in the furnace.

CRANES.

The writer's experience in the crane industry goes back to the period when the application of steam power was still a novelty, and when hand and hydraulic cranes, chiefly the former, were in service. The applications of air and electricity were not as yet entertained. There are many cranes yet in existence which date very long prior to that period. Some of these, of uncertain age, are timber framed, with stones for balance, and having barrel wheels with spider-like arms and narrow teeth, and are keyed on square shafts. Some of these are still doing occasional work. Many are of the well type—that is, in which the post of cast-iron goes down deeply into the ground, and is stepped into a casting at the bottom of a well of masonry. This type is often half a century and upwards old. Such cranes are still working within a radius of a few miles of the writer's home. The contrast between cranes of this kind and the modern types is sufficiently startling to call for some observations thereon.

A number of circumstances have combined to bring about this change. It is not only that the demand for labour-saving devices in handling material has become as great a feature in modern industry as the demand for increased production of machine tools. But for the fact that many developments have greatly favoured the growth of big and highly mobile cranes, we should not yet have seen giants capable of lifting a couple of hundred tons, of a hundred feet radius, and bridge cranes of 200 ft. span and more. As long as timber, cast-iron, hand, and steam-power were the principal elements available, growth could not be very rapid. Massive cranes were made then, but they were clumsy and slow. Not until the possibilities introduced by steel, electricity, and air were available, could cranes, powerful, light, and highly mobile be produced. The subject is too wide to be adequately treated here, but we can indicate some of the reasons why progress has been possible. In massive cranes the dead weight of the members composing the framing is very great, and when either cast, or solid-plated, it increases the dead load, and the load to be moved. The small dimensions in which wrought iron was rolled rendered heavy built-up plating very expensive. We say *was*, because wrought iron is now practically quite out of the running as far as the plated work of cranes is concerned. But the large dimensions available in steel plates have enabled the crane makers to build the biggest and strongest structures, with the minimum of dead weight. Instances which occur to the mind are the Benrath cranes at Bremerhaven, Brown hoisting machines, the Temperley transporters, the numerous coaling cranes, and the overhead travellers.

In the heavier cranes, the electric conductors have done away with much dead weight, substituting motors and controllers for boilers and engines, or for massive water cylinders and chains. The dead weight of crabs and trolleys is lessened thereby, and there is less vibration at high speeds. None but those who know the herculean, slow, and risky tasks involved in hauling and lifting loads about in shops which are inadequately supplied with power cranes can fully appreciate the value of the light air hoists now becoming common. They are so easily transported and handled, and so rapid in action, that in those shops where large quantities of comparatively light work are handled, the jib cranes and overhead travellers cannot enter into successful rivalry with them. They have but one, the electric hoist, which also is developing in the hands of a few manufacturers.

Another line of cranes which has been developed largely by the use of steel and electricity is the portal, or gantry cranes, for dock and wharf service. The old wharf cranes blocked the roadway, and when operated by water, lines of pipes liable to freeze often gave trouble The portal cranes reach clear over the road, and take current readily. Their framings are braced and light, lessening weight to be moved, and their jibs, often curved, and high up, command the work to be done more efficiently than when they are stepped into the old type of portable wharf crane. There is no branch of engineering, not even machine tool construction, which is advancing more rapidly than crane manufacture and design, and none which is of greater interest to those who know the practice of earlier years.

PAGE'S MAGAZINE

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OUR MONTHLY RESUMÉ.

LONDON, 20th September, 1902.

The Largest Ship Afloat.

The largest vessel ever built was launched last month from Messrs. Harland and Wolff's Shipbuilding Works, Belfast, for the White Star Line. This new vessel, which is named the *Cedric*, is 700 ft. long. Her beam is 75 ft. (7 ft. more than the *Oceanic*) and her depth is 49½ ft. She is about 21,000 tons gross. The displacement at her load draught will be 37,870 tons. The *Cedric* has nine decks. She is built on the cellular double-bottom principle, and is divided into numerous watertight compartments, so that a maximum of security is obtained exceeding all official requirements. The *Cedric's* engines, which are of the Harland and Wolff quadruple-expansion balanced type, will drive her at her designed speed with considerably less consumption of coal than is required for a vessel of extreme speed. The *Cedric*, like the *Celtic*, will have accommodation in all for about 3,000 passengers, besides quarters for a crew of about 350. The newly-launched ship is being fitted up in fine style, and we may have more to say about her hereafter.

The Cunard Line and the Combine.

It is now reported that the arrangement by which the Cunard Line is to receive a large augmentation of the Government subsidy hitherto paid for mail carrying is practically complete, and that it is a condition that the line shall remain "all British." It is said that Mr. Pierpont Morgan was in active negotiation for the acquisition of this line, and that pourparlers to this end had been carried to a certain point, when an obstacle arose in the attitude of the chairman, Lord Inverclyde, who "put his foot down" when it appeared that the effect of the proposals would be to transfer the control of the line to America. The details of the Cunard arrangement are not known up to the time of writing. As to the lines at present controlled by the Morgan Combine, Liverpool is to be the chief centre in this country, and the British management will be localised there. Mr. Wilding, of the Leyland Line, is to be the general manager. There will be a concentration of the present separate offices and staffs, and all will be combined in the building which the late Mr. Ismay constructed in James Street for the purposes of the White Star Line.

New Battleships. Tenders are now at the Admiralty for the construction of the only battleship to be built by contract under the 1902 Naval Programme, and also for the machinery of the battleship to be built at Portsmouth Dockyard. Both vessels are of the same class as the *King Edward VII.*, now building at Devonport Dockyard; the *Commonwealth*, building at Fairfield; and the *Dominion*, building at the Vickers Company's works at Barrow-in-Furness. These vessels are 425 ft. long, 78 ft. beam, and of 43 ft. moulded depth; and with a draft of 26 ft. 9 in. they will displace 16,350 tons. The five vessels now included in this class are 1,350 tons greater than any of the ships-of-the-line in the British Navy. In speed, however, they will be behind the six vessels of the *Duncan* class now being completed, which will steam 19 knots on their full-power trials, while the new ships will make 18½ knots. The engine power is the same, 18,000 i.h.p.; but more weight is given to armour and guns in the new vessels. Their complete broadside is covered from 5 ft. below the water line to the upper deck with hardened plates, varying from 9 in. to 7 in., and right forward to the ram, where the armour is 4 in. in thickness. These ships, in addition to the usual twin pairs of 12-in. guns in barbettes, will carry four 9·2-in. guns in four smaller barbettes, as well as ten 6-in. quick-firers, fourteen 12-pounders, ten 3-pounders, and two Maxim guns, with five submerged tubes for firing torpedoes. This armament is superior to that of any ship in the Navy. The machinery will be much the same as that of the *King Edward VII.*, which has a combination of Babcock and Wilcox and cylindrical boilers. There will be four cylinders working on the triple-compound principle, the high-pressure cylinder being 38 in., the intermediate 60 in., and the two low-pressure cylinders 67 in. in diameter, with a stroke in each case of 48 in. The full power will be realised with 120 revolutions. The contract ship will have cylindrical boilers for one-fifth of the power, and Babcock and Wilcox boilers for the remainder. The Dockyard-built ship will have Niclausse boilers for four-fifths of the power, the remainder being got from cylindrical boilers worked under the Howden system. The boiler pressure in both cases will be 210 lbs. per square inch.

British Tonnage. The *Shipping Register* for July shows that there has been an unusually large production of new tonnage, and that the loss of tonnage from various causes has been remarkably slight. The result is a large addition to our merchant fleet. Of new steel steamers, no fewer than forty-nine, with a gross tonnage of 120,045 tons, were added to the *Register* during the month. With iron and small wooden vessels the total additions are seventy-nine ships of 121,896 gross tons. The removals from the *Register* comprised only eight steamers of 15,573 gross tons, twelve iron steamers of 5,701 gross tons, and wooden steamers and sailing vessels of various types, bringing the total up to sixty ships of 32,743 gross tons. These do not include vessels transferred to and from the Colonial Registry. Deducting 32,743 tons from 121,896 leaves a difference of 89,153 gross tons as the net addition to the *Register* during the month.

The "Massilia." Another new Anchor Liner has been built by Messrs. Alexander Stephen and Sons (Limited), Glasgow. This vessel, which is named the *Massilia*, is of the following dimensions:—Length, 400 ft.; breadth, 49 ft.; depth, 30 ft. 9 in. moulded; with a gross tonnage of 5,100 tons. She will be supplied with a set of triple-expansion engines, the cylinders being 26-in., 43-in., and 71-in. diameter, by 4 ft. stroke. There will be two double-ended boilers working at a pressure of 180 lbs. This latest addition to the Anchor Line fleet is intended for their Indian service, and has been built to the highest class of the British Corporation Registry. The main saloon, a very handsome apartment situated on the bridge deck, is well lighted and ventilated, and provides superior accommodation for a large number of first-class passengers. The decoration is bright and artistic, and the furniture and general appointments are very handsome. The state-rooms are aft of the main saloon, and consist of large, airy, and well-lighted two- and four-berthed rooms. From the main saloon a handsome stairway leads to the promenade deck, where a spacious music-room is provided. At the other end of the promenade deck there is a large and well-ventilated smoking-room. The vessel has been fitted with all the latest improvements for the rapid working of the large cargo which she has been designed to carry, including ten powerful steam winches. An insulated chamber for storing meat and vegetables has been provided, which will be kept constantly cool by a large refrigerating machine placed in the engine-room.

New Turbine Steamers.

The success of the two turbine passenger steamers on the Clyde is calling forth various projects for the further utilisation of this class of sea motor. One is to be employed in the cross-Channel service, between Dover and Calais. We are informed that Messrs. Denny, of Dumbarton, have received from the South Eastern and Chatham Companies an order for a turbine steamer for next season's traffic, which for speed, comfort, and convenience will revolutionise the cross-Channel passage. The Dover-Calais route will be the first sea passage upon which this new type of steamer will be employed. The length of the vessel is to be 300 ft., and she will have a beam of 40 ft., which is 5 ft. to 6ft. wider than any present cross-Channel steamer. This will give a magnificent deck space, and add to the vessel's stability at sea, prevent rolling, and reduce the inconvenience of passengers to a minimum. The ship will be provided with every up-to-date convenience for such a steamer, and will be entirely different from the present type of mail packet. The upper, or promenade deck, is to have an overhead shelter, so that in rough weather passengers can be protected without going below. This new steamer will be provided with extensive cabin accommodation. The turbine machinery occupies such a small space compared with the present heavy engines and machinery, that a vast amount of additional room will in this way be obtained for the use of passengers. As to speed, it is calculated that the cross-Channel passage will be covered by this steamer in 45 minutes at the outside, and probably, under favourable conditions, in less. The steamer will have five propellers, and be fitted with rolling chocks to add to her steadiness at sea, and her engines will be capable of producing a speed of about 25 knots an hour without vibration. At present the highest average cross-Channel steaming is 1 hour 5 minutes. Another project has reference to the building of a large and swift turbine boat for the West Highland tourist trade.

Marking Time on the Rand.

The present position in Johannesburg is one approaching stagnation, as only about one-third of the stamps are working, and there seems to be a lack of strong initiative on the part of the mining interests to terminate the present slump by a settled and combined policy with regard to the restricted supplies of unskilled labour and transport, which on the surface of things constitute the obstacles to renewed progress. Counsels are divided, as will be indicated by the following propositions, for dealing with the labour question, which are advocated in various quarters :—

1. The offer of larger wages to Kaffirs.
2. The importation of Indian coolie labour.
3. The introduction of Chinese.
4. Giving white unskilled labourers five shillings per day, with free food and quarters.
5. The letting of underground contracts to gangs of white men.

The first plan would undoubtedly be the most satisfactory solution if a return of the rates prevailing before the war would result in a sufficiency of labour, but it is probable that so much money had to be distributed among the natives in various ways during the war, that only exorbitant prices would bring them into Johannesburg in sufficient quantities.

The second and third propositions are strongly opposed on the grounds that large numbers of Indians or Chinese are undesirable residents in a white man's country. The experience of Natal has shown that of the coolies imported for plantation working to that country, a large proportion of them, on the termination of their indentures, elect to remain as permanent residents. The writer had the opportunity of watching an experimental application of coolie labour on the Rand in the early nineties, and the results observed were not encouraging. In Australia, again, the people have had considerable experience of Chinese immigration, and the efforts of the local Parliaments are directed towards its restriction.

Racial difficulties. The fourth suggestion is opposed by the skilled white workmen on the ground that it would tend to reduce workmen's wages all round, and there seems to be some ground for this fear. Nevertheless, at the present moment this idea is receiving the most effectual support in influential quarters. Some of the companies are building a number of rooms for the occupation of white labourers on these terms, which are at present only offered to men discharged from military service. Another difficulty in connection with this plan is the necessity for the complete separation of the white from the black labour. It will be apparent to everyone that if white men and Kaffirs were employed on the same work in mixed gangs, a fatal blow would be struck at the prestige of the white man, and results of the loss of caste upon the internal affairs of the country might easily be disastrous. It is therefore generally conceded that this separation of blacks and whites must be maintained. That is to say, that if any particular mine employs cheap white labour, say on the surface, then the whole of the surface work should be done by whites. Even with this limitation the Kaffirs will soon realise that white men are employed on the same kind of work as themselves, and this will make them less amenable to the white man's rule. This political aspect of the case seems therefore to be the most serious one.

The last proposition has much to recommend it from the mine manager's point of view, but if the contracts were let at such prices that the cost to the companies per ton milled suffered no increase, the men would probably not earn more than £4 per week, and from a miner's point of view it is certainly more pleasant to receive £5 10s. for supervising Kaffirs than £4 as the result of a week's hard personal labour.

The Outlook. In conclusion, then, it may be safely said that the tendency is distinctly towards the reduction of all salaries and wages, and that until the present conditions of stagnation and uncertainty have given place to the vigorous prosecution of some definite policy, such as is usually characteristic of the able men in whose hands lie the the future of the Rand, it is impossible to recommend any one of any calling to venture there at the present time unless his prospects are assured before leaving his home. The other difficulty referred to above, namely, in regard to transport, also affects progress considerably. Merchants cannot get more than one-third of their requirements sent forward on the railways, and batteries have to shut down owing to shortage of coal, and slimes plants stop for want of lime. We have endeavoured to give a true picture of present conditions, and its colours are not rosy; nevertheless, there is plenty of hope for the future, for the gold is still there, and there is little doubt that within twelve months and perhaps less, this district will again be the scene of activity and prosperity that it has been in the past.

Although less money may be earned per head, the amount spent in necessaries will also become gradually lessened, and that spent on whisky considerably reduced.

Occurrence of Fire Damp. Fire damp has always attracted attention in connection with coal mining, and still does; in fact, if this attention is relaxed the world is soon painfully reminded of the presence of this undesirable concomitant of coal by some direful calamity due to the effects of its sudden appearance and combustion. Some very interesting and careful experiments have been made recently, more particularly to verify points of doubt and variance existing in relation to the work of previous investigators. In some experiments samples of coal of 16-lbs. weight were pulverised by means of steel balls in a closed gas-tight cylinder, which at the start was exhausted of air and then revolved thirty-five turns a minute. After an hour the pressure of any gas in the cylinder was ascertained, the volume measured, and the composition determined. Two varieties of coal were investigated, and both yielded gas in variable quantities. Neither the chemical composition of the coal, nor its density, nor the degree of fineness of the pulverisation, seemed to bear any relation to the volume or character of the gas evolved. More gas was obtained by making two exhaustions of the cylinder each after half an hour's attrition than by a single exhaustion after one hour; this was due to some re-absorption of the gas by the coal. Coal in lumps loses its gas slowly, the combustible constituents are the first to go.

Sudden Outbursts.

This solitary fact of the occlusion of fire damp in coal having been established and scientifically demonstrated, provides, it is asserted, an explanation for all the phenomena associated with beds that are subject to sudden outbursts of gas, and also for all the conditions under which the outbursts are produced.

Precautions.

Exploratory borings should be employed, and should prove useful in indicating the probable spots where sudden outbursts of gas may be expected; but this exploratory work should not be relegated to an under-manager, neither should the position and directions of the holes be arranged by some fixed rule. The work, to have real effect, should not be left to subordinates, but should be under superior direction and should be conducted and modified so as to ascertain the peculiarities and character of each particular seam, then necessary and effective arrangements could be made to avert calamity. Such is the latest decision in this important matter. It is particularly urgent to take precautions in times when earth movements are prevalent, as the resulting disturbances are liable to set free great volumes of pent-up fire-damp.

Coal Dust Dangers.

Many and often have the dangers of coal dust impressed themselves on the public mind in a painful manner; many and often have warnings been issued about this danger, and just as often have folks neglected these warnings, and even questioned the dangerous character of dust. To such an extent has this been the case, that the Governments of our own and various other countries have held inquiries into the matter, and by searching experiment have obtained proof of the undoubtedly dangerous character of coal dust. Yet what does all this avail? One of our own Colonies furnishes a terrible example of the fact that it avails but little.

Canada's Warning.

In the Fernie mines of the Crow's Nest Pass Coal Company, we find the chief mining superintendent, in charge of a dry and dusty mine, never had the dust analysed or otherwise tested to ascertain whether it was explosive or not, neither did he have the dust removed or watered in old workings, because he considered it impracticable; and the only method of watering the dust employed anywhere in the mine under his direction was with a car and can. Moreover, the foreman and other officials of the mine were also unacquainted with the dangerous character of coal dust. Result—a violent explosion when 152 men were working in the mine. All the splendid efforts to succour and save resulted in the rescue of twenty-two men, who were already in the last throes of a death struggle with after-damp. And the jury, the Government expert, the miners' committee, and a former manager of the mine were unanimous in asserting that the explosion was caused by coal dust. Even the chief mining superintendent, already mentioned, admitted that the explosion might have resulted from his inability to remove or water the dust in the old workings. There are 50 widows and 60 families bereft by this accident. Such are the terrible lessons necessary to make some people realise that the statements and warnings of the scientific investigators are really of vital importance and worthy of serious consideration.

Government Locations.

The Canadian Government have made a move which is highly appreciated by many people throughout the Dominion, inasmuch as the Minister of the Interior has selected an extensive area in the above-mentioned coal district, which, by the way, is situate on the boundary between British Columbia and Alberta, and is said to be one of the best locations in that region. The coal of the particular neighbourhood shows on tests 74 to 79 per cent. of carbon and from 2 to 4 per cent. of ash; it is clean and firm, and yields a high-grade coke. Strangely enough, there has been such activity in the location of claims in this field, that it was only by a surveyor's error that the area now taken up by the Government was not already appropriated.

Healthy Competition.

Besides the value of the property to the Government, the acquisition has another advantage in that it introduces an element of competition which was much desired, not only to reduce prices, but to ensure more active working and a better supply. The Crow's Nest Pass Coal Company has been in operation nearly five years, and has reached an output of 2,000 tons a day; but on one outcrop seam, where work was commenced in 1898, production has not yet reached 500 tons a day.

Asbestos in Canada.

This mineral is an important factor in Canada's mining industries, and one that shows signs of agreeable vitality. In 1879, 300 tons were produced, valued at 19,500 dols.; last year the output was 38,500 tons, valued at 962,500 dols., showing an increase of 7,859 tons above the production for the year 1900. In the latter year the Province of Quebec produced 21,408 tons, thus giving employment to 1,040 workmen. The mineral is obtained by open cast workings or quarries, in which power drills and other up-to-date appliances are employed. Blondin cableways being used to take the material from the quarry to the mill.

Asbestos Enterprises.

There are in Canada twelve companies at work, with a capital of four millions, and employing 3,000 men. Bell's Asbestos Company, which is probably the best known, furnishes a good example of a successful asbestos enterprise. The capital is £700,000, of which £170,000 has been issued and paid up in full. Large profits have been earned annually from the working of the company's mines, and dividends as high as 22½ per cent. have been paid. Canada, in fact, controls the asbestos market of the world.

Canada's Nickel.

This is another valuable mineral product prevalent in the Dominion. Several of the great nickel-producing companies have already combined; nevertheless there is plenty of activity in the famous nickel region of Ontario, where there are at present extensive supplies of ore; in fact, it is so plentiful that only the richer bodies are being worked, and should these fail, the smelters could be supplied by the concentration of the poorer ores.

Process Wanted.

Many interesting and useful investigations, experiments, and trials with various processes, including, *inter alia*, magnetic separation, the ingenious Mond process, and the direct steel process, have been conducted with the nickeliferous copper ores, and have yielded valuable results. Nevertheless, heap-roasting, matte-smelting, and Bessemerising are employed wherever the ore is being treated on a large scale. Where the blast furnace is used on pulverised matte there is considerable loss in the shape of flue dust, which briquetting would only in part prevent.

China-clay in France.

Deposits of China-clay have long been known to exist in the department of the Drôme; a single deposit has been observed to extend for 1,700 ft. or more. There are four quarries quite ready for working, and there are works at Barbière, at the present time, producing 20 tons of kaolin and designed to produce from 50 to 60 tons. The operations conducted consist in washing the sand from the clay. The latter is disposed of for porcelain and pottery, the former is stored for special use.

Professor Perry on the Education of the Engineer.

At a recent meeting of the British Association, Professor John Perry, the well-known authority on engineering matters, delivered some pointed remarks concerning the training of the young engineer, and the influence of education upon our commercial supremacy. The present system of teaching mathematics and the undue importance attached to classics formed the subject of a scathing attack. "I have known the ordinary abominable system of mathematical study," he said, "to be advocated by engineers, who, because they have passed through it themselves, have really come to loathe all kinds of mathematics higher than that of the grocer and the housekeeper. They say that mathematics have trained their minds, but they do not need it in their profession. There is no profession which so much requires a man to always have the mathematical tool ready for use on all sorts of problems. The average schoolboy leaves an English school with no power to think for himself, with a hatred for books, with less than none of the knowledge which might help him to understand what he sees; and he has learnt what is called "mathematics" in such a fashion that he hates the sight of an algebraic expression all his life after." Professor Perry evidently thinks there is something radically and seriously wrong with our method of training boys for the professions generally; and that improvement lies in the direction of a system by which the pupil's reflective faculties are stimulated, and he is trained to *think* intelligently. Upon this firm and healthy basis, the Professor sees our future commercial supremacy securely established. We note with interest the robust common-sense view which Professor Perry takes of England's position as a commercial nation.

The sound judgment characterising the following extract, will, we think, be a sufficient excuse for our quoting it at length.

British Commercial Supremacy.

"No right-thinking engineer has been scared by the newspaper writers who tell us of our loss of supremacy in manufacture, but I think that every engineer sees the necessity for reform in many of our ways, and especially in this of education. People talk of the good done to our workmen's ideas by the strike of two years ago; it is to be hoped that the employers' ideas were also expanded by their having been forced to travel and to see that their shops were quite out of date. In fact we have all got to see that there is far too much unskilled labour among workmen, foremen and managers, and especially in owners. Millions of money may build up trusts, but they will be wasted if the unskilled labour of mere clerks is expected to take the place of the thoughtful skilled labour of owners and managers.

I laugh at the idea that any country has better workmen than ours, and I consider the education of our workmen to be the corner-stone of prosperity in all engineering manufacture. It is from him in countless ways that all hints leading to great inventions come. New countries like America and Germany have their chance just now; they are starting, without having to 'scrap' any old machinery or old ideas, with the latest machinery and the latest ideas. For them also the time will come when their machines will be getting out of date, and the cost of 'scrapping' will loom large in their eyes. In the meantime they have taught us lessons, and this greatest of all lessons—that unless we look ahead with much judgment, unless we take reasonable precautions, unless we pay some regard to the fact that the cleverest people in several nations are hungry for our trade and jealous of our supremacy, we may for a time lose a little of that supremacy. We have been too confident that manufactures and commerce and skill in engineering would remain with us for ever. We have had a very strong hint given us that we cannot for ever go on with absolutely no education in the scientific principles which underlie all engineering.

There is another important thing to remember. Should foreigners get the notion that we are decaying, we shall no longer have our industries kept up by an influx of clever Uitlanders, and we are much too much in the habit of forgetting what we owe to foreigners, Fleming and German, Hollander, Huguenot, and Hebrew, for the development of our natural resources. Think of how much we sometimes owe to one foreigner like the late Sir William Siemens.

In our country nearly all discoveries come from below. The leaders of science, the inventors, receive from a thousand obscure sources the germs of their great discoveries and inventions. When every unit of the population is familiar with scientific ideas our leaders will not only be more numerous, but they will be individually greater. And it is we, and not the schoolmasters, who are familiarising the people with a better knowledge of nature. When men can hardly take a step without seeing steam engines and electro-motors and telegraphs and telephones and steamships, with drainage and waterworks, with railways and electric tramways and motor cars, when every shop window is filled with the products of engineering enterprise, it is getting rather difficult for people to have any belief in evil spirits and witchcraft. All the heart-breaking preaching of enthusiasts in education would produce very little effect upon an old society like that of England if it were not for the engineer."

The Steel Amalgamation.

The rumours which have been so prevalent recently with regard to the formation of a colossal amalgamation of British steel interests have not been confirmed. The issuing of a circular, however, to the shareholders of Messrs. Dorman, Long and Co., is of interest. It announces that the directors have decided to enter into a "provisional agreement to purchase from Sir Lowthian Bell and his family 30,000 shares of £5 each, with £3 10s. paid up, being the remaining half of the ordinary shares of Bell Brothers, Ltd., thus constituting Dorman, Long and Co., Ltd., the owners of all the ordinary shares in that company, the consideration being the issue to Sir Lowthian Bell and his family of ordinary shares in Dorman, Long and Co., Ltd., of the nominal value of £225,000." This sum represents as nearly as possible the value at par of the shares in Messrs. Bell Brothers, Ltd., together with half the reserves and unassigned profits shown in the balance-sheet of the latter company. It may be remembered that Messrs. Dorman, Long, and Co., Ltd., assisted in the flotation of Sir Lowthian Bell's company in 1899, by purchasing one half of the ordinary shares. The capital of the purchasing company is also to be increased by the issuing of £250,000 in ordinary shares, which will be offered to its shareholders at par in the proportion of one-third of their present holdings, any surplus which is not thus appropriated (not exceeding 125,000 shares) being similarly allotted to Mr. Hugh Bell and Mr. A. J. Dorman. The prosperity of Messrs. Dorman, Long and Co. has fluctuated considerably during recent years, with the vagaries of varying trade; but they have always been well to the front in the contest for British supremacy in the iron and steel industry. They have neither hesitated to adopt new methods of business, nor neglected the advantages of thoroughly up-to-date equipment. At present the company's mills and furnaces are being remodelled and enlarged.

The Decrease in the American Export Trade.

The report of Mr. Bell, the British Commercial Agent in the United States, recently published by the Foreign Office, announces an enormous decrease in the American export trade, especially in iron and steel manufactures. The total value of the exports during the fiscal year, ending June 30th, shows a falling off of 104,980,945 dols. (about £25,000,000). These figures will come somewhat as a surprise to the British public, and, looked at casually, are likely to convey a false impression with regard to American prosperity. Notwithstanding this striking discrepancy between the trade of the last two years, it is a fact that the American factories and workshops of almost all industries have been working at their full pressure; but owing to the unprecedented demands for home consumption, American manufacturers have found a readier, and more profitable market for their goods at home. Especially is this true with regard to the iron and steel industry, which has been greatly stimulated by the remarkable prosperity of the railways. These have not only been purchasing rails extensively, but have been obliged to obtain much additional rolling-stock and general supplies, thus increasing the demand for a great deal of other material produced by iron and steel manufacturers. Mr. Bell states that the American furnaces have been utterly unable to meet the unparalleled demand for iron and steel for home use; and it has been found necessary to import considerable quantities of raw, semi-manufactured, and even manufactured material. At present, the boom in the home markets shows no signs of abating. It is estimated that the American railways will require at least 2,000,000 tons of steel rails alone for the ensuing year; and orders for 1,000,000 tons have already been given. We gather from Mr. Bell's report, however, that this prosperity is not likely to be protracted, for American manufacturers are already preparing for a time when it will be essential for them to take their products further afield.

"It is only too evident," says Mr. Bell, "that preparations are being made to meet this contingency. Railways are either combining or forming communities of interest with a view to carrying goods as economically as possible, especially towards the seaboard. The shipping interests have the same thing in view, so that by the time the supply greatly exceeds the demand in this country everything will be in readiness to carry the surplus to Europe and other countries more economically than has ever been done before. The large Trusts are preparing for that time. The large financial interests in New York and other centres have become so mixed up with railway, industrial, and shipping concerns that they are able to exert an enormous influence with the transportation companies in order to obtain favourable rates of transport for the Trusts' merchandise. The latest of the great combines, the Atlantic Shipping, is doubtless part of this great scheme. In the meantime, those British manufacturers who have not already done so will have an opportunity of remodelling their works, and placing them in a condition to be able to meet in a more satisfactory manner the inevitable and severe competition."

The Uniformity of Trade Catalogues.

Too much attention cannot be paid to the production of trade catalogues. It is a recognised fact that the firms which provide up-to-date and attractive descriptions of their goods are in the front rank of successful business enterprise. Much has been done in recent years to make the trade catalogue a work which will be scanned with real interest, instead of being thrown aside as a dry category of goods and their prices. In one important particular, however, there appears to be much room for improvement. Many firms, in striving after the artistic, are prone to neglect the utilitarian features of their publications, and hence we have catalogues of many varying sizes—some wider than they are high, or too high to take their place on the book-shelf where they can be conveniently referred to. There appears to be a growing understanding on the part of engineering firms that catalogues should conform as nearly as possible to the dimensions of 6 in. by 9 in. The importance of this is very apparent. In the offices of nine out of every ten engineering firms it is the custom to file all catalogues received, in order that they may be referred to at a moment's notice; and thus the catalogue of awkward shape and size is often relegated to the waste-paper basket, or stacked with other ungainly literature upon the office floor. Thus it is not readily to hand when wanted, and the consequence is that another firm, issuing a catalogue of more modest dimensions, will often secure the order. In some cases the unavoidable necessity of illustration by large diagrams will prevent an adherence to the uniform standard; but it is generally possible to issue an auxiliary volume of uniform size, and money spent in this direction will generally prove a paying investment.

NOTABLE BRITISH PAPERS OF THE MONTH.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of Great Britain.

MEETING OF THE IRON AND STEEL INSTITUTE AT DÜSSELDORF.

THE summer meeting of the Iron and Steel Institute at Düsseldorf presented many points of interest, not the least important of which was the warm welcome extended to the members by German metallurgists and engineers, who not only did the honours of the occasion with marked spontaneity, but were ready to throw open the more important German works for the inspection of the visitors, a concession which was greatly appreciated.

The proceedings opened with a meeting of the Council at the Tonhalle on September 3rd, when the formal reception of the President, Council, and members by the representatives of the Government, civic authorities, and the Reception Committee, was followed by a selection of papers. In the afternoon an adjournment was made to the Exhibition, where, under the guidance of English-speaking experts, groups were formed for the purpose of examining the various sections of mining, metallurgy, and machinery. On the following day a somewhat similar programme, varied by social gatherings, was carried out. The Friday was devoted entirely to visiting works.

For this purpose five groups were formed, proceeding respectively to Essen (the Krupp Establishment), Dortmund (the "Union" Company, the Hoerde Works, the Hösch Steelworks), Ruhrort (the Phœnix Works, the "Rheinische Stahlwerke"), Oberhausen (the Gutehoffnungshütte), Duisburg (the Vulcan Works, the Duisburger Maschinenbau Actien-Gesellschaft, formerly Bechen and Keetman). Supplementary excursions were also arranged, and a special programme of visits and excursions was drawn up for the ladies attending the meeting.

A word should be said in praise of the detailed programme arranged by the secretary, Mr. Bennett H. Brough, including excellent plans of Düsseldorf and the Exhibition, and a map of the district, as well as much useful information on the subject of German money, cab fares, electric tramways, etc. These, with special local notes, and a section devoted to the works to be visited, formed a handy guide for the use of members.

In the following pages we reproduce a selection of the papers read at the Düsseldorf meeting, and regret that pressure upon our space prevents the inclusion of a larger number of excerpts. Besides those which are here dealt with in detail, papers were contributed by Professor H. Wedding on Iron and Steel at the Düsseldorf Exhibition; by Messrs. E. D. Campbell and M. B. Kennedy, of the University of Michigan, on the Probable Existence of a New Carbide of Iron; by Messrs. L. F. Gjers and J. H. Harrison, of Middlesbrough, on Results obtained in the Equalisation of the Temperature of Hot Blast; by M. A. Harmet, of St. Etienne, on the Compression of Steel in Ingot Moulds; and by Professor E. Heyn, of Berlin, on the Overheating of Mild Steel.

THE USE OF ELECTRICITY IN IRON AND STEEL WORKS.

AN excellent paper on the above subject, from which we take the following excerpts, was read at the Düsseldorf meeting of the Iron and Steel Institute, by Mr. F. Kylberg, of Benrath. The author describes various American appliances which have been adapted to European requirements:—

In recent years, as is generally known, the application of electricity to the driving of mechanical appliances in ironworks has grown to an unprecedented extent. This may be due primarily to the fact that the cost of generating the electric current has been reduced beyond all previous conception, and the time is even now within measurable distance when modern central power stations driven by blast-furnace gas will render the use of electric power in iron and steel works practice still more general. In fact, it appears probable that at no distant date both auxiliary steam engines and hydraulic power will be entirely superseded.

Hitherto the necessity has existed of laying down extensive steam-boiler installations, for the heating of which either coal or blast-furnace gas was required. Despite every effort to effect a reduction in the consumption of steam by the introduction of central condensing and cooling plants, as well as by increasing the efficiency of the steam engine, it was nevertheless found impossible to lower the cost of generating the power by these means till it approximated to that attainable by the use of direct-driven gas engines. The blast-furnace owner of the present day can, in fact, avail himself of a free supply of thousands of horse-power. Further developments in this direction will no doubt lead to modifications in the construction of the blast-furnace and to the perfection of it, not only as a pig-iron producer, but also as a gas producer. This, again, involves the adoption of the requisite modern gas-purifying plant, the need for which had formerly never been experienced.

The development of the blast-furnace gas engine and the electric potential possibilities thus opened up gave occasion to the metallurgical engineer to employ this energy in driving machinery of every conceivable variety. The American works in particular, which are laid out for production on a large scale, have achieved wonders in the use of electricity, although they have only recently begun to employ gas-driven engines. These American appliances have often been introduced into Europe without regard as to whether they were adapted to European conditions, with the consequent result of occasional failure. The author proposes in the following paper to describe some developments based on American experience and adapted to European requirements.

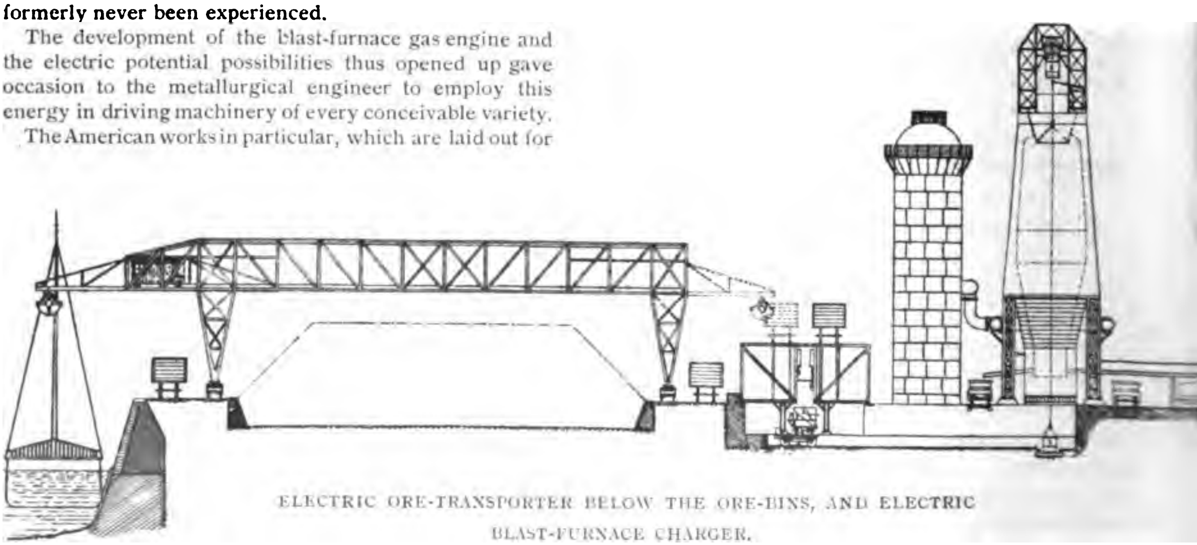
ELECTRIC SHUNTING AND MINE LOCOMOTIVES.

The great advantages of the utilisation of electric power as compared with steam are particularly noticeable in this connection, as is proved by the reduction in the cost of working and an efficiency hitherto unattainable. The following are the two types of locomotives which have proved most serviceable; first, the shunting locomotive of medium tractive power and high speed; and secondly, mine locomotives of high tractive power and low speed. Both of these types are distinguishable from one another chiefly by their general mode of construction. The following are the chief points in the construction of standard electric locomotives. Each axle is driven by a special motor, by which means great efficiency and high tractive power are assured. The motors are, moreover, arranged that any one of them can be cut out if desired, and as the result the speed of the engine can be regulated according to the load. The shocks experienced at starting and stopping are also less severe.

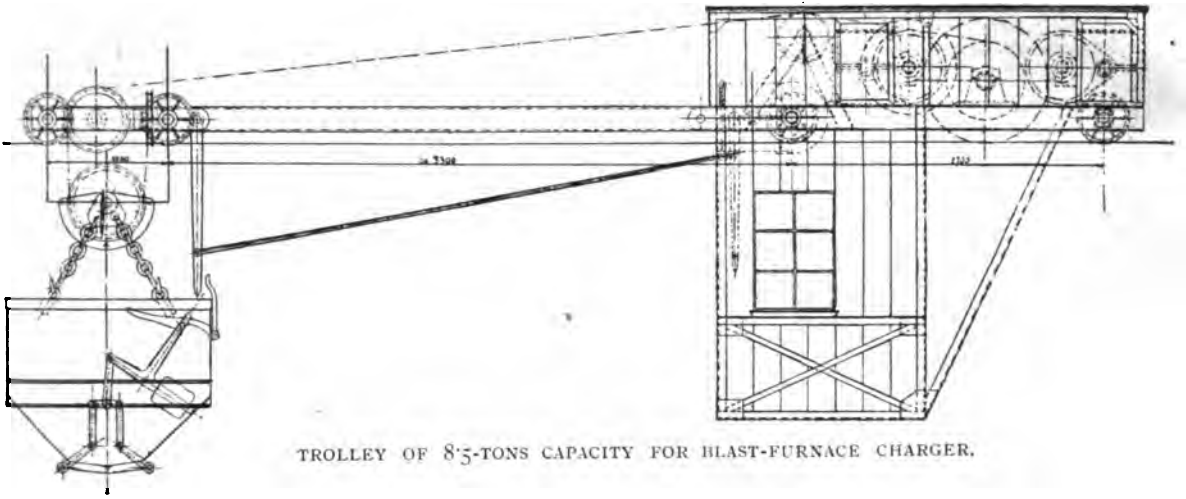
In the smaller steel works where the use of locomotives would not be profitable, electrically driven capstans can be employed to advantage. The driving mechanism of these capstans is enclosed in water-tight cast-iron casings, which are placed beneath the level of the platform so that only the round warping end of the capstan projects. These capstans are usually constructed with a tractive power of five tons.

ORE AND COAL TRANSPORTING APPLIANCES.

The construction of ore and coal unloading appliances was first developed in the United States; an arrangement



ELECTRIC ORE-TRANSPORTER BELOW THE ORE-BINS, AND ELECTRIC BLAST-FURNACE CHARGER.



TROLLEY OF 8·5-TONS CAPACITY FOR BLAST-FURNACE CHARGER.

of this kind being indeed necessitated by the vast quantities of coal and ore which required transportation n the harbours or ironworks in that country. The Brown Hoisting Company was the pioneer in this respect, and has earned for itself, both in America and in Europe, a well-deserved reputation. The unloading arrangements correspond in their general features to the construction adopted by the Benrath Engineering Company, which pays special attention to the avoidance of the use of wire ropes. The transport of the materials upon the overhead track is effected by means of an electrically driven trolley, equipped with a hoisting arrangement of simple design. This trolley can be constructed with either one or two jibs, within the range of which are the ship at the one extremity and the railway track at the other. The transporting capacity of the Brown conveyers is considerable, varying between 80 and 100 tons of ore or coal per hour. It is a further advantage of this system that for the manipulation of the entire transporter only one operator is necessary. Moreover, after each lift that portion of the jib projecting over the ship is automatically drawn back, so that either the ship can be warped or the travelling bridge be moved along without the necessity of folding up any part of the bridge.

ELECTRICALLY DRIVEN ORE-TRANSPORTING ARRANGEMENTS BENEATH THE ORE BINS AND THE ELECTRIC BLAST-FURNACE CHARGER.

After the ores have been conveyed to the ore tipping ground or to the ore bins by means of the transporter previously described, it is an essential condition that the ore and coke should be transferred to the top of the blast-furnace with the least possible handling and cost of labour. For the performance of this work also electric energy is admirably adapted.

In the design of a charging apparatus described by the author, particular attention had been paid to the following points :—

(1) The whole of the mechanism was driven electrically.

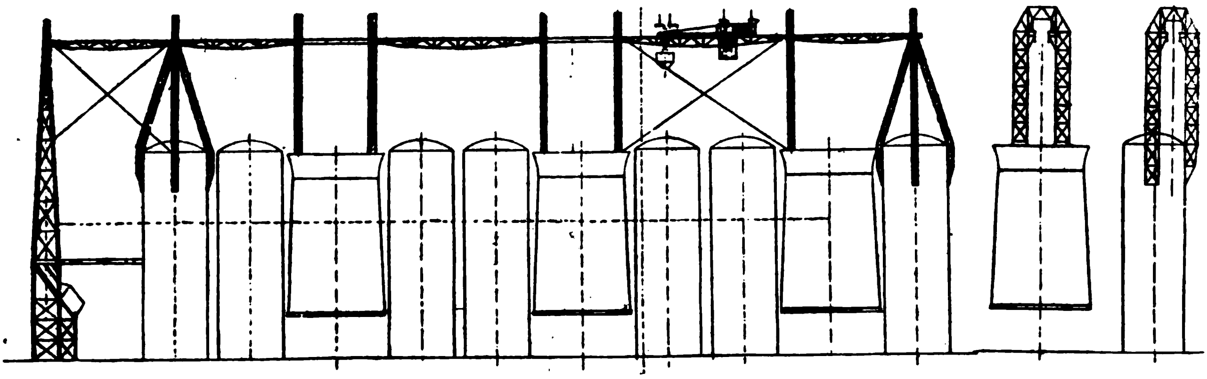
(2) Hopper-shaped trolleys were provided to run beneath the ore bins.

(3) A single hoisting arrangement served several blast-furnaces.

Parallel to the row of blast-furnaces are arranged the two ore and coal bins, which are filled direct by the ore transporter or from the railway cars on a track above them. Below these bins runs a hopper trolley, which can be filled from any one of the bins above it. A platform is built along the row of blast-furnaces, which convey the hopper to the hoist, where it is tipped into the hoisting skip. This skip is attached to a trolley, which is provided with a hoisting gear and runs on an elevated track above the blast-furnaces. The skip after hoisting is conveyed by means of this trolley to any one of the furnaces, and the contents are automatically discharged on to the bell. Assuming that a single charge which the bell is capable of supporting amounts to 10 tons, the arrangement above described can deal with a quantity amounting to 200 tons per hour.

AN ELECTRICALLY DRIVEN TILTING ARRANGEMENT FOR MIXERS, OPEN-HEARTH FURNACES, AND CONVERTERS.

For this purpose also electric power can be suitably applied. The large heavy pig-iron mixers were hitherto operated by means of one or two hydraulic cylinders, an arrangement that can now be replaced by a combination of levers, which receive their motion direct from a motor and crank. The motor is placed as far as possible from the mixer, so that in pouring in the molten metal the risk of injury by the splashing of the metal is avoided, and it is not too much exposed to the excessive heat. As regards the arrangement of motors for tilting the converter, this is in accordance with the details previously given in the case of the mixer, and the power is transmitted by means of spur-wheel and worm-gearing. The power necessary for tipping the mixer or for tilting the open-hearth furnace amounts to about 7 h.p., and the time required for the performance of the operation is not more than half a minute. For the converter, on the



BLAST-FURNACE CHARGING PLANT OF 8·5-TONS CAPACITY.

other hand, since the contents of this must also be lifted, the requisite power is about 60 h.p., and the time in this case is about one minute.

ELECTRIC ADJUSTER FOR INGOT CARS.

In most of the American open-hearth steelworks the method has now for several years been followed of pouring the metal direct into the ingot moulds when standing on small cars. By this plan the whole of the time and labour in the casting pit is saved. At the Differdingen works also this system was introduced some years ago, and is working with signal success.

The charge from the open-hearth steel furnace is tapped direct into a casting ladle, and is conveyed to a platform at one end of the casting shed. Here the steel is poured into the ingot moulds mounted on the cars, which latter are drawn forward one by one upon a track alongside of the casting platform. In order to adjust the ingot cars without moving the crane, an electric adjusting gear for pulling forward the cars is provided, and an arrangement of this description was constructed for the Differdingen works by the Benrath Engineering Company.

THE FURTHER PROCESS OF HANDLING INGOTS IN STEELWORKS BY MEANS OF (1) ELECTRICALLY DRIVEN STRIPPING CRANES, (2) COMBINED SOAKING PIT AND STRIPPING CRANES, (3) SOAKING PIT CRANES.

As a necessary adjunct to the above-mentioned method of the direct casting of ingots upon cars, the ingot stripper plays an important part. Such machines, of various design, were first constructed by the practical Americans. In the latter types, electricity as the driving medium has replaced hydraulic power. The difficulties which had to be overcome in order to adapt electricity to this purpose lay in the fact that the pressure to be exerted is very considerable in order to force out the hot ingot from the ingot mould. By the employment of screwed spindles the problem was at length solved, and there are now several such ingot strippers with screwed spindles in active operation. The ordinary electrically driven ingot stripper only draws the mould from off the ingot, and afterwards places the empty mould upon another car provided for the purpose in the neighbourhood. There is, on the other hand, an entirely new kind of construction, which is better adapted for production on a small scale. This is a combination of a stripper and soaking pit crane, by means of which it is possible first to strip off the mould and afterwards to pick up the ingots with the same tongs and convey them to the soaking pits. After reheating they are extracted and carried by the same crane to the live rollers. An electrically driven soaking pit crane with automatic gripping tongs, with the raising and lowering of the ingots effected by means of a screwed spindle, and one operator only necessary for the service of the crane and manipulation of the tongs, has been in operation for several years at the Differdingen works, and from the time that it was first put into operation has worked admirably, dealing with the entire production of ingots made at these works.

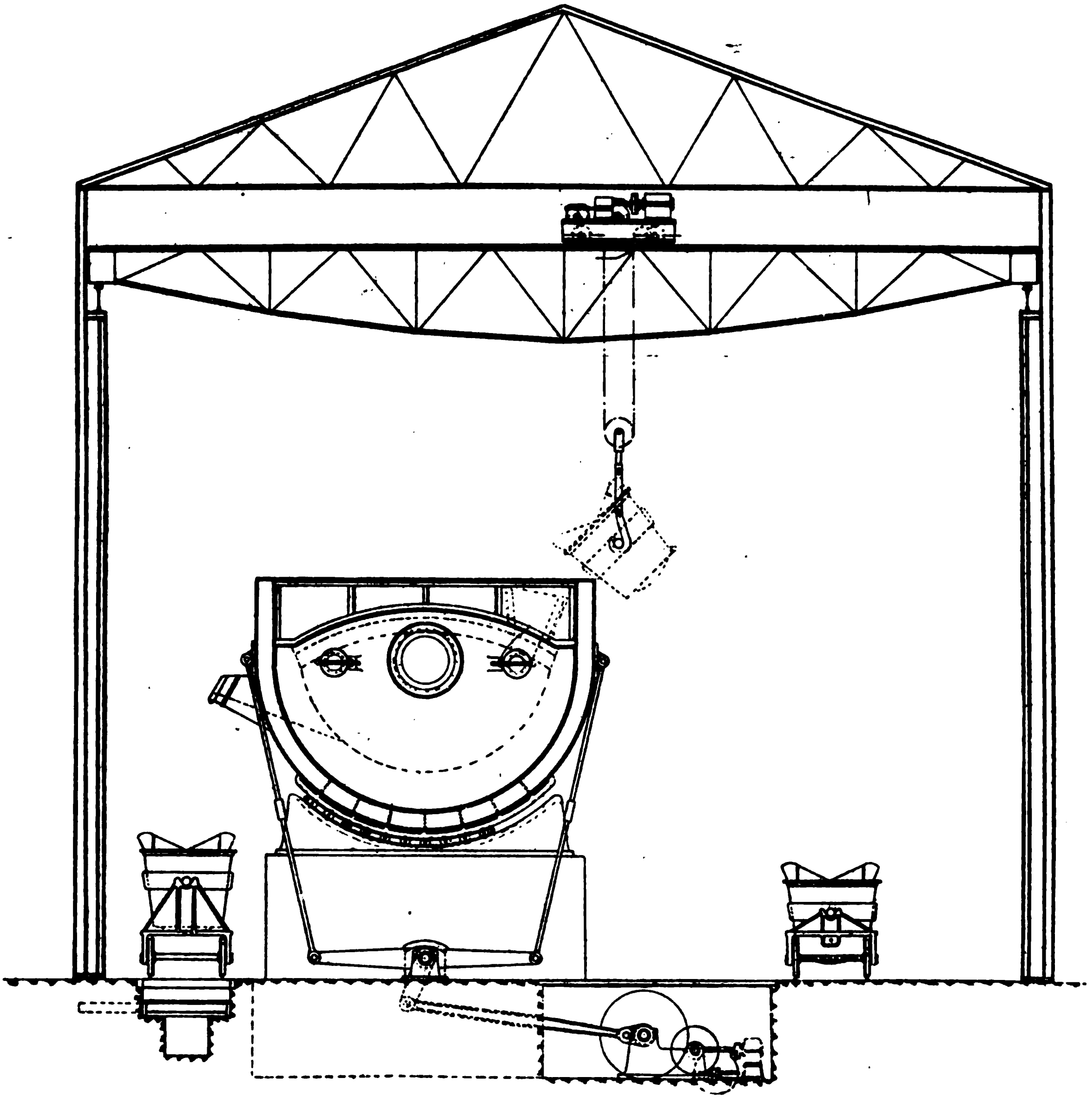
In this connection might be mentioned the well-known charging machine for open-hearth and horizontal reheating furnaces, by means of which considerable economy in power is secured, as well as in increased efficiency of the steelworks. These machines also bear further testimony to the advantage of applying electricity as a source of power in the steel-making industry.

ELECTRICAL APPLIANCE FOR LIFTING THE SOAKING PIT COVERS.

Among the more recent electrical appliances for iron and steel works may be mentioned the lever combination for raising the lids of soaking pits. By the adoption of this arrangement hydraulic cylinders, which are ordinarily used to pick up and carry away the covers of these pits, can be dispensed with. The apparatus is constructed to span one to three rows of soaking pits, and is able to serve a very large number of these.

LIVE ROLLER DRIVING GEAR.

In the general construction of electric driving gear for live rollers, as usually carried out, two motors are used for the heavier roller trains for ingots or for long transporting trains of rollers. In other cases a simple driving gear with one motor is employed for standard roller trains of lighter construction. These trains of rollers are so well known that to describe them in detail here would



HEATED PIG-IRON MIXER (WITH ELECTRIC TILTING ARRANGEMENT).

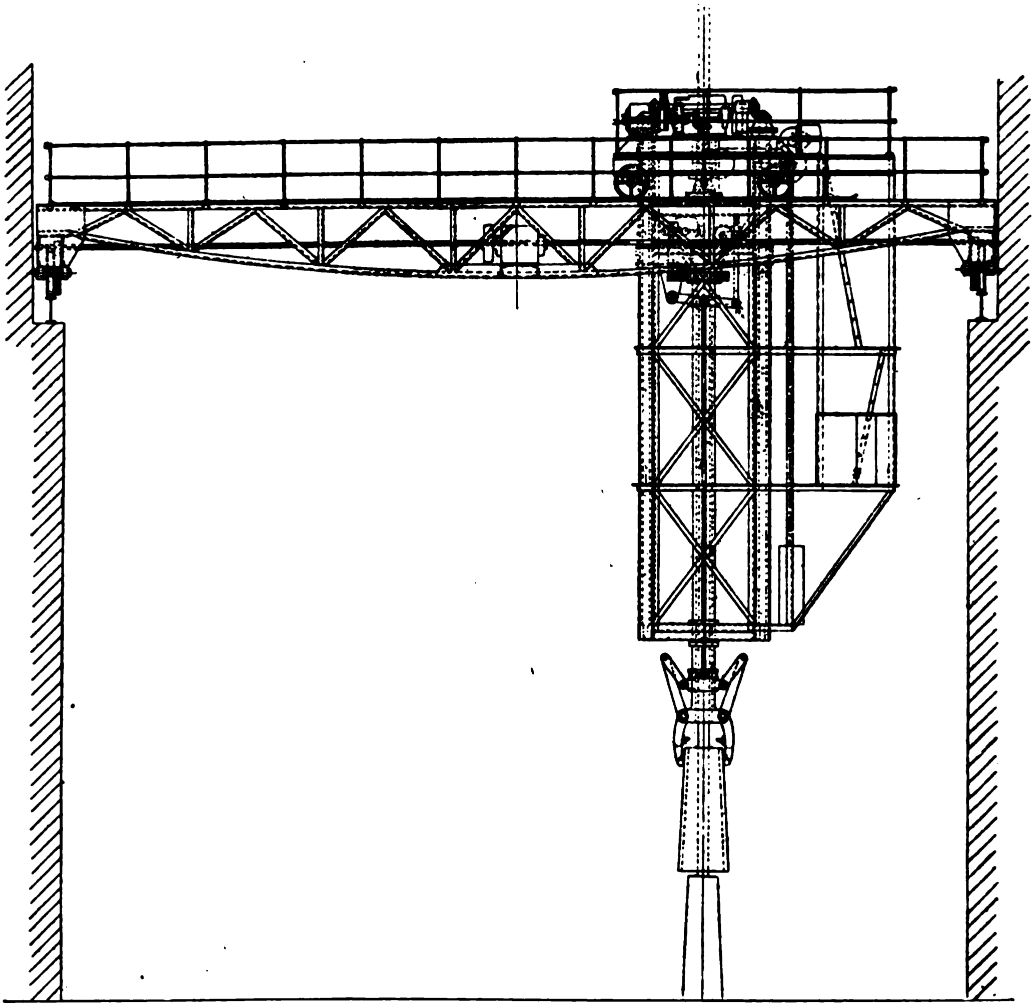
be superfluous. It is only necessary to remark that this method of driving them is greatly superior to the ordinary methods of steam driving. It has unfortunately been impossible to give diagrams and other data in connection with these electric roller driving gears on account of the shortness of time available, but the author hopes on a future occasion to be able to give fuller details.

COGGING TRAIN WITH ELECTRICALLY DRIVEN LIVE ROLLER GEAR, ROLL SCREWING GEAR, UPSETTING AND TRANSFERRING GEAR.

A cogging train with live rollers illustrated by Mr. Kylberg was designed exclusively for electric driving :—

A novel arrangement in connection with this cogging mill, which so far as the author is aware has never hitherto been put in operation in Europe, is the electric screw gear for the adjustment of the upper roll. This arrangement was first designed in 1895 by the firm of Mackintosh Hemphill and Co., in Pittsburg, for the various rolling mills of the Bethlehem Iron and Steel Company. At first the arrangement consisted of an electric motor, placed between the two housings, for the adjustment of the upper roll. A great difficulty was, however, experienced in keeping the motor cool, on account of the proximity to the heavy slabs and the exposure to the great heat which radiated from these.

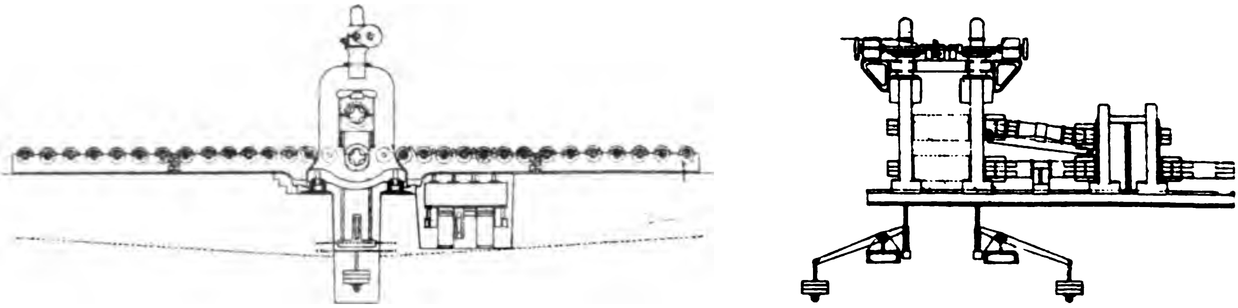
In 1889, when the Bethlehem steel works were taken over by the Carnegie interests, and were re-erected in



COMBINED PIT AND STRIPPING CRANE.

Homestead, it was soon found necessary to alter the method of driving, and the whole of the motors for actuating the screwing gear were placed at one side of the building, the motion being transmitted by means of belts. This system was further modified by the Wellman, Seaver Company, who constructed an electric adjusting gear in which one motor only was employed, which was fixed on the outer side of the housing.

These adjusting gears were inspected by the author on the occasion of a visit to Alabama, near Birmingham, and their working was all that could be desired. The driving was effected by means of an electric motor 100 h.p.



COGGING TRAIN.

The arrangement described in the present paper has the advantage, as compared with the American design, that the driving of the screw adjusting gear is effected by means of two motors, one on either side of the housing. Either motor can be cut out, or they can work together in the same manner as described in the earlier portion of the paper, by which means the speed of adjustment can be varied as desired. The system of two motors ensures, besides, a greater precision of action, and in case either motor is incapacitated from any cause, the other would still be sufficient to perform the necessary work of adjustment.

The upsetting and transferring gear is also electrically operated in many instances, and the hydraulic arrangements hitherto in vogue have been superseded.

ELECTRICALLY DRIVEN HOT SAW.

For cutting the sections as they come from the finishing rolls various kinds of swinging saws, driven by steam, have been invented. In all these arrangements the advancement of the saw was always effected by means of the hydraulic cylinder. An electric counterbalanced hot saw is made intended to replace the hydraulic cylinder, the saw itself being also driven by an electric motor. With this hot saw girders of a depth of 550 millimetres (22 in.) can be cut. The diameter of the disc is 1,500 millimeters (4 ft. 11 in.), and the velocity at the periphery is 60 meters per second (198 ft.). The power necessary for driving the saw is about 60 h.p., and it is capable of making five cuts per minute.

ADJUSTABLE STOP FOR REGULATING THE LENGTH OF GIRDERS CUT BY THE HOT SAW.

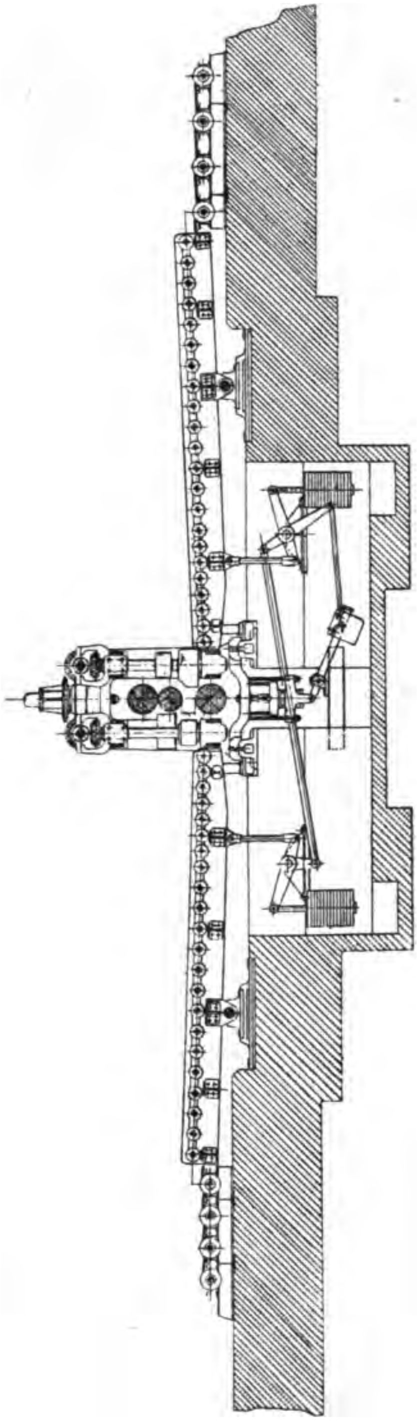
This arrangement is exceedingly convenient for adjusting the length of the material to be cut and the length of the different sections; it permits a variation in the size of the bars of 5 metres. A 7-h.p. motor is used for adjusting the stops which determine the length of the girder, and the stops can be traversed throughout their entire range within half a minute. The bars and girders can, therefore, be dealt with with absolute regularity as they come finished from the mill.

HOT BED WITH ELECTRIC TRANSFERRING GEAR.

The transport of the sections upon the hot bed can also be effected by an electric transferring gear, which is actuated by wire ropes driven by a motor. An appliance of this kind presents no striking novelty, but is worthy of mention in order to complete the enumeration of the various mechanical devices employed in a steelworks. These gears can be constructed to handle light or heavy sections, and several such transferrers can be provided in one hot bed. They should, however, be independent of each other, and a separate motor of 2 h.p. can be supplied for driving them. By their means girders can be turned over and placed upright if desired.

ELECTRICALLY DRIVEN LIFTING TABLE FOR PLATE ROLLING AND WIRE ROLLING MILLS.

An example of this is furnished by a universal three-high rolling mill with an electrically driven lifting table



UNIVERSAL THREE-HIGH ROLLING MILL.

and a central roll adjustable by electrical means. Lifting tables of this kind have been in successful operation for several years past in America, and, in the author's opinion, the employment of such apparatus in European steelworks would be extremely advantageous. A rolling mill equipped with lifting tables of this description is at work at the Carnegie Steel Company's works in Pittsburg, and the author noted on the occasion of his visit that they were capable of being reversed twenty times per minute without overstraining the motors in any way. In general the following principle may be taken as applicable in the standard practice of electric driving in ironworks: that the motors should be of as nearly as possible the same power and type. By this means the cost of repair is lessened, and the changing of the working parts when worn out can be more easily effected.

In conclusion, the paper describes the advantages of electrically driven rolling mills and cranes:—

CANTILEVER CRANES.

In the stock-yard of a large ironworks it is also of considerable advantage to employ the system of cranes known as cantilever cranes, which traverse the whole length of the yard, and are so constructed that the projecting arms of the centre crane can just touch the outer extremities of the two outside cranes. By means of this arrangement the expensive structural ironwork for long runways can be dispensed with, and the entire yard can be served by means of this most simple arrangement. A further advantage also consists in the great economy of power in transporting comparatively light loads, since a single heavy crane need not be employed. In order to reduce as much as possible the great number of revolutions of the electric motors, a worm-gearing can be employed with advantage. These have now been brought to so great a state of perfection that an efficiency of 90 per cent. has been obtained.

THE APPLICATION OF ELECTRIC POWER IN THE IRON AND STEEL INDUSTRIES.

At the Düsseldorf meeting of the Iron and Steel Institute an instructive paper on the above subject was read by Mr. D. Selby-Bigge, of Newcastle-on-Tyne. In placing this paper before the Iron and Steel Institute, the author's one endeavour has evidently been to show what are the immense possibilities and advantages to be derived from carefully considered electric power schemes. He has succeeded in putting the subject forward plainly and in a practical light, the thirty-two pages of his valuable contribution containing data, information, and subjects for much thought and consideration.

SAVINGS EFFECTED IN WORKS.

For the Hamburg quayside cranes the total working expenses were as follows: Wages for cranesmen, coal or electric current, cleaning and oil (excluding, however, repairs) per ten hour run per crane, taking the average during the year:—

	Cost per Ten Hour Run.	
1. Brown single steam crane	10s.	
2. Steam-winch crane...	8s.	1893-94
3. Steam crane driven through pipes from steam plant...	12s.	
4. Electric crane	7s.	1898

In 1901 the working cost of 182 Brown's cranes came to 11s. 4d. per crane per ten hour run, whereas that of the electric cranes was the same as in 1898, viz., 7s.

In 1898 the steam cranes lifted 1,825,880 tons in 315,083 hours, the working costs amounting to £20,516 4s., so that the cost per hour (inclusive of repairs) amounted to 410,324 ÷ 315,083 = 1·302 shillings, or about 1s. 4d. per working hour.

The cost per ton lifted would be 0·2247 of a shilling, or nearly 2¾d.

The electric cranes lifted, from January 1st, 1898, to September 30th, 1898, 77,697 tons in 10,190 working hours, the costs being 2,664 shillings for current (2d. per K.W., hour) and 4,462 for wages, etc. Thus for one ton of goods lifted, the cost is nearly 1d.

Taking next the case of the Westinghouse Air Brake Company, Wilmerding, Penn., U.S.A., the boilers in this shop were formerly driven in groups, 30 steam engines, aggregating 1,375 h.p. being used for the purpose. The engines were supplied with steam from the central boiler plant. For this system was substituted an alternating current system, the generators supplying induction motors driven by Parsons' steam turbines; the shafting used was divided into shorter lengths, and the 30 engines were replaced by 57 motors, aggregating 1,065 h.p. In order to have an accurate comparison of the two systems, several tests were made, extending over some days, with the following results: The reduction in steam consumption was found to be 40 per cent., and the reduction in coal consumption $32\frac{8}{10}$.

Before a meeting of the Franklin Institute in 1901, Mr. Samuel Vauclain, Superintendent of the Baldwin Locomotive Works at Philadelphia, U.S.A., stated that if electric driving in their works should be abandoned, the manufactured product would cost 20 to 25 per cent. more for labour, and the floor space would have to be increased 40 per cent. to maintain the present output.

At a large colliery in South Durham the pumps were originally of the spear rod type, worked from bank, and the pumps delivered about 1,000 gallons per minute against a head of 400 feet.

Owing to the room which these pumps occupied in the shaft, and it being desired to put in another cage, which could not be done with the pumps in the shaft, the pumps were removed and in their place was substituted a horizontal compound coupled engine of 400 h.p., one 250 K.W. dynamo arranged to drive the two pumps at present installed, also an additional pump, and the coal cutting machines.

This machinery was placed at a colliery where they were able to utilise coke oven gas. The colliery being 1,000 yards from the shaft where the pumps were originally installed, the current was carried overhead by cables and down the shaft by two sets of 11 by 18 three-throw pumps, each delivering 500 gallons per minute against a head of 400 feet.

It is estimated that the saving in fuel alone is over £1,500 per annum; in addition to this the shaft can now be used for winding, and the output of the colliery very considerably increased.

In one of the collieries in Northumberland the workings were pumped by means of seven single-barrel pumps, each set delivering about 100 gallons per minute, these pumps being driven by an endless wire rope from two hauling engines, steam being supplied by locomotive boilers underground.

This plant was taken out, and in its place was substituted a horizontal engine with automatic triple expansion gear driven on to a dynamo, and the existing pumps were utilised, the pumps being driven through machine-cut worm gear by 6-h.p. motors, and in all eight sets were so arranged.

The total cost of the electric plant, exclusive of erection, was a little over £3,000, and the annual saving was from £1,500 to £1,800.

The author then proceeds to give other very interesting examples of savings effected in works, which we regret we have not space to reproduce.

COST OF PRODUCTION.

The author has frequently been asked a very obvious and reasonable question, viz., what is the cost of production should we adopt an electric plant in our works? In answer to this the author has drawn upon a number of cases of different kinds and in different parts of the country, showing the rate at which the works owner can generate his own electricity. These figures are taken from actual examples of every-day working, and are not in any way test figures taken for the purpose of this paper. Taking these figures as a basis, it is an easy matter for a works owner, once having ascertained the total horse-power which will be involved in the driving and lighting of the entire works, to see for himself at what expenditure per annum he can run his works upon the new system.

COST OF ELECTRICITY DELIVERED ON SWITCHBOARD.

Test of 139½ *hours, November* 17*th to* 23*rd*, 1901, *Britannia Works.*

Mean current (amps.)	3,464
Mean pressure (volts)	125
Mean power (watts)	433,000
Mean electric horse-power	580·42
Board of Trade units	60,403
Weight of steam per B.T.U.	27·52 lbs.
Weight of coal per B.T.U.	3·04 lbs.

Cost per B.T.U.	d.	Cost per week.
Coal 3·04 lbs. at 11s. 6d. per ton... ...	0·187	£47 4 0
Water 27·52 lbs. at 3½d. per 1,000 gallons	0·00963	2 8 6
Stores...	0·00995	2 10 0
Wages	0·06625	16 13 3
Repairs*	0·0159	4 0 0
Superintendence	0·01192	3 0 0
Net cost per B.T.U.	0·30065d.	£75 15 9
Interest and Depreciation on £15,000 at 10 per cent. per annum...	0·099d. per unit.	

COST PER E.H.P. PER HOUR.	
Coal 2·27 lbs. at 11s. 6d. per ton	0·1395
Water 20·53 lbs. at 3½d. per 1,000 gallons	0·00718
Stores	0·0074
Wages	6·0404
Repairs	0·01185
Superintendence	0·0089
	0·22423d.

Mean I.H P. at 75 per cent. efficiency, 773. Coal per I.H.P., 1·705 lbs
Water per I.H.P., 154 lbs.

The author is indebted to Messrs. Richardson, Westgarth and Co., Ltd., West Hartlepool, for the following information on the subject of the economy effected by the introduction of electric driving into their works. The following is a rough summary of the changes which have been effected:—

These works were formerly driven by about thirteen small and uneconomical steam-engines scattered about in different places, the maximum aggregate indicated horse-power of which would approximately be, say, 300 to 400.

Steam for these engines was furnished by a battery of twelve boilers, and the coal consumption for the driving of the works was approximately 100 tons of coal per week.

Five years ago the driving arrangement of the works was remodelled by the substitution of electric-motors for the various engines—a power-house being built in a central position, and equipped with two boilers, each 15 in. by 10 in., two dynamos, each of about 400 i.h.p., and one small machine of about 120 h.p.

The tools throughout the works are now giving an output at least of 30 per cent. in excess of what it used to be, and are burning from 50 to 60 tons of coal per week for the generating station boilers.

The above facts speak for themselves with regard to the economies which have been brought about by the introduction of electric-driving into the works.

The machinery throughout was constructed by Brown, Boveri and Co., and is of the three-phase alternating current type.

The cost of renewal and repairs over the period during which the machinery has been running (five years) has been extremely small, certainly not 1 per cent. of the value of the installation.

The managing director of a large engine-works informed the author that they are now running their works on 7½ tons of coal per day, and are employing 800 men.

Their work consists of four distinct yards, all yards are driven from one central station, and in the old method a boiler would have to be placed in each department or else long lines of wasteful steam-pipe.

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* Includes labour of keeping 134 arc lamps in repair.

Their cost of production, including interest and depreciation on capital, is 0·46 of a penny per unit.

At a shipyard on the north-east coast, using only 112 h.p., the cost of production of electricity has been found to be only 0·6 of a penny per electrical horse-power per hour, this figure including all charges, interest, and depreciation.

At another shipyard on the north-east coast the saving effected by the substitution of electricity for steam driving shows a saving of 43½ per cent. per £ wages paid by the adoption of electric power.

The figures are as follows :—

COST OF POWER PER £ WAGES PAID.

Coal and Gas.

May 2nd, 1893, to April 24th, 1894.

Wages	£64,885
Cost of power	2,337

= 8·66d. per £ wages paid.

Electricity.

April 30th, 1900, to April 30th, 1901.

Wages	£126,700
Cost of power	2,578

= 4·88d. per £ wages paid.

Taking the case of another shipyard which was previously driven by gas engines, the author has received the following particulars: "We have no hesitation in saying that we are getting at least 30 per cent. more power out of our machines since we adopted electric power instead of the gas engines we used before.

"As far as the cost per B.T.U. goes, we have lately had readings taken, and find that last year's works out at about 0·8 of a penny; this is taking into consideration the depreciation on our plant, interest on capital, repairs, and in fact everything which we can possibly put down against this account."

The average output would not exceed 250 to 300 horse-power.

The author is indebted to the managing director of another large shipyard in the North of England for the following statement: "Some years ago just about the time when we first introduced electrically driven machines we put in new boilers in place of the old ones, and while it must be remembered that the new boilers are more efficient than the old ones, I would say in general terms that our coal consumption has been reduced by some 40 per cent., although the amount of machines driven electrically is now greater than those which were formerly driven by steam, and consequently the reduction may be even greater than the percentage I mention above."

In a letter the author has received from Colonel R. E. Crompton, he states :—

"In our works, which are on a somewhat extended scale, the substitution of electric driving for the old shafting system has approximately halved our bill for power ; in fact, the whole of the driving of the works and tools for about 1,300 men is practically supplied by one 120 K.W. set fully loaded, and it is only when we are testing that we have to run two sets of this size, whereas by the old system we should have had to run two 200 h.p. engines continuously."

In summarising the above cases, it is obvious that the greatest economy results in the substitution of electricity for steam in those cases where the units of power, both in engines and boilers, are the most subdivided.

There are, however, enormous advantages to be derived, especially in the case of intermittently working machinery, where the load is of a very variable nature, and particularly so in all crane work, which plays such an important part in all our engineering industries.

MACHINERY TESTS.

The author then gives an entirely new and complete schedule of tests, which have been carefully and accurately obtained by members of his staff during the past few months, and he trusts that engineers and managers of works may find these figures of some practical service and guide to them in deciding upon the horse-power of motors to be adopted for the driving of various classes of machinery. The list will be found to embrace the greater part of those tools usually found in all engineering establishments.

THE DEVELOPMENT OF ELECTRIC POWER COMPANIES.

During the past two years great activity has been displayed in England in the formation of large electric companies, dealing with extensive tracts of country and covering under their parliamentary powers vast areas for the supply of electricity in bulk to tramway companies, electric light companies, works owners, and for manufacturing purposes generally.

In certain cases, and under favourable conditions, with regard to the district to be supplied, these companies may meet with success, but in many cases the author is of opinion the matter has been rushed into somewhat precipitately. Taking, for instance, a district of a fairly concentrated character, or in which a large number of small works and factories exist, absorbing each, say, 100 to 200 horse-power, it might be found that with the power company supplying them with electricity at 1d. per unit it would be more profitable and convenient to them to obtain their power from the company in preference to laying down their own plant. In cases such as this, the power companies should have a good field before them. When, however, the power company enters the field in districts where all the works are of an extensive character, and absorb 500 to 5,000 horse-power in electric current each, the case changes its aspect, and it will be found that it will be more profitable for the works owners to produce their own power.

On examining closely the cost of production of electricity by works owners in their own works, it is quite clear that with generating stations of 400 horse-power and upwards, equipped with economical and modern appliances in the shape of high-pressure boilers, mechanical stokers, triple expansion condensing engines, working with superheated steam, etc., the cost of production should not exceed ½d. per Board of Trade Unit, inclusive of interest and depreciation on the capital outlay. With blast-furnace waste gases this figure would be still less.

The author is of opinion that in the case of power stations in works dealing with 1,000 h.p. and upwards, and laid down upon the most modern lines, this cost of production can be reduced to 0·4d. per B.T.U., as shown in the case of Messrs. Dorman, Long and Co.'s works.

ADVANTAGES OF WORKS BEING DRIVEN ELECTRICALLY.

We have in Great Brttain been somewhat slow in making use of all the advantages which electricity has enabled us to reap. In many parts are to be found the same old low-pressure boilers, which have done service for the past thirty years, with working pressures as low as 15 lbs. per square inch. In other works are still to be found the same old beam engines constructed in the days of Watt and Stephenson. Works are still to be found in which over 100 small high-pressure and non-condensing engines are distributed with their mileage of steam pipes throughout the works—little or no attempt having been made to improve this state of affairs. It is in cases such as these the author trusts this paper may be of service, by showing clearly and in a practical manner the actual result which would accrue from the remodelling of the driving arrangements upon the electrical method.

In no country have we finer examples before us of the achievements of electricity as a motive power than in Germany, and we must all admire the skill, ingenuity and, above all, the enterprise of our German friends in this direction.

There are many outlying advantages which would accrue were works and industrial establishments driven electrically. There would be an enormous reduction in the smoke produced in large manufacturing centres, and a proportionate increase in a healthier state of things for the inhabitants.

In these days, when the idea of coalfields giving out is mooted, there would be a perceptible difference in the quantity of our coal consumption, which, although perhaps unpalatable to the coal-owner, would be most welcome to the manufacturer, who aims at the lowest cost of production. The application of electric power to the iron and steel, engineering, and manufacturing industries in Great Britain has certainly not developed with anything like the rapidity with which it has progressed in America and on the Continent.

THE POSITION OF THE ENGLISH WORKS MANAGER.

Generally speaking, the powers and responsibility vested in the general manager of a works in England are very different to what they are in a works in America. There the position is one of much greater latitude in the scope of innovations and improvements, and of responsibility also.

The actual result, therefore, is that improvements and savings are rapidly carried out, and the board of directors look to their manager for the expected improvement and savings, owing to the manager's minute knowledge of the details of the scheme he is putting forward and his great sense of responsibility in the matter. In the author's experience in dealing with firms in England, he has most frequently been struck with the small scope of initiative action allotted to the works manager, nearly every innovation and improvement being referred to the board of directors. This in a very large degree appears to be the cause of a retarding influence on electric power progress in our country.

In brief, the scope and responsibility vested in the works manager in America is very different to that allotted to the works manager in England. The board of directors' decision is responsible for the results obtained, and the works manager carries out the wishes of the board; on the other side the works manager is directly responsible to the board for the innovations that have been carried out.

There is one point that has most forcibly struck the author in dealing with improvement schemes for works. Outside of our own country he has invariably been met with a first question, "What is the saving to be effected under the proposed scheme?" In England the first question put is, "What is the cost going to be?"

Both are naturally very important considerations, but many is the time that really great and immediate savings have been left unconsidered by that one glance at the first cost, and the documents have been pigeon-holed and shelved, only to be brought out when absolute necessity, not real enterprise, compelled them to be resorted to again.

In the many uses to which electricity has been applied as motive power, none has proved more suitable than its application to shipyards, dockyards, and other works of this description possessing a great number of scattered and intermittently working machines. Our great dockyards both at home and abroad offer a case in which enormous savings could be effected. The reduction in working costs of a number of shipyards with which the author is acquainted has varied between 30 per cent. and 60 per ceut. If this same saving could be effected in similar establishments, such as our Government dockyards, the result would be highly beneficial to the country.

THE PROGRESS AND MANUFACTURE OF PIG IRON IN GERMANY SINCE 1880.

At the Düsseldorf meeting of the Iron and Steel Institute, Mr. W. Brügmann, ot Dortmund, read a notable paper dealing with the unprecedented development of the German iron industry.

A comparison of the entire world's production of pig iron (18,300,000 tons) in 1880 with that given for 1901 (over 39,000,000 tons) shows that in this period the production of pig iron has been more than doubled. Almost the whole of this increase may be apportioned between the two countries, Germany and the United States. In 1880, the United States ranked second among the iron-producing countries, with a production of 3,895,000 tons, equal to half the production of Great Britain at that time, and Germany occupied the third place, with 2,729,000 tons, or about one-third of the English output. In the year 1900 there were produced in America 14 million tons; in England 8·962 million tons; and in Germany 8·351 million tons. The production of the United States is therefore more than three and a half times, and that of Germany more than three times, greater at the present time than in 1880, while that of England shows but a moderate increase.

The author then touches briefly upon the conditions which have led to the vast increase in the manufacture of pig-iron in Germany.

Notwithstanding the unprecedented development of the German iron industry, the blast-furnace works of the country have not been able to meet the demand. In the last ten years, 1891 to 1900, the excess imports have amounted to 1·8 million tons of pig and scrap iron. It must, however, be borne in mind here that the favourable condition of the iron industry during the last few years has had much to do with this, since of that quantity more than one million tons were imported during the two years 1899 and 1900. It is probable, however, that in the succeeding years a change will occur, since in 1901 the exports exceeded the imports by 100,000 tons, and in the first half of 1902 by 330,000 tons.

Mr. Brügmann then takes *seriatim* the following seven districts, and gives numerous statistics concerning the iron smelting works there established:—

(1) Rhenish Westphalia, exclusive of the Saar district and the Siegerland; (2) The Siegerland, the Lahn district, and Hesse-Nassau; (3) Silesia and Pomerania; (4) The kingdom of Saxony; (5) Hanover and Brunswick; (6) Bavaria, Würtemberg, Thuringia; (7) The Saar region, Lorraine, and Luxemburg.

THE MECHANICAL APPLIANCES OF GERMAN BLAST-FURNACES.

The improvements in the mechanical appliances of German blast-furnaces are best judged by the fact that the workmen employed in the blast-furnace industry in 1880 numbered 22,000. At the present day some 35,000 are employed, notwithstanding the production being more than treble that of the previous period. The improvements in the appliances for transport of raw material and iron have chiefly contributed to this reduction in the proportion of manual labour.

Extensive shunting stations with central signal-boxes, and weigh-bridges with hydraulic or electric counter-balancing arrangements, have been laid out. By means of these the long trains of ore waggons can be conveyed in a minimum of time to the raised tracks laid over the ore tipping ground. It is particularly essential that those works situated in the coal district, which obtain their ore from abroad, should possess facilities for stocking several cargoes within a few days. The necessary space for stocking large quantities in ore-bins is generally provided beneath the tracks on to which the ore waggons are run. The waggons themselves for transporting the ore are self-discharging, being fitted with flap side-doors The Talbot waggon is arranged to discharge its load on either side of the track.

Unloading appliances of American type (Hunt and Brown) are employed to convey the ore from the holds of vessels to the furnace-yard. The Krafftwerk at Kratzwieck, near Stettin, the Vulcan at Duisburg, the Krupp works at Rheinhausen, the Union Company at Dortmund, all have installations of this kind.

Aerial wire ropeways exist in almost every ironworks. The firm of Pohlig and that of Bleichert have constructed a number of remarkable systems of ropeways. These are often employed to convey the ore or coke direct to the top of the furnaces, or for the removal of the crushed slag. At the Henrichshütte at Hattingen the whole of the raw material is carried to the blast-furnace by means of these suspended tracks.

Where it is not the practice to grind the slag, it is got rid of by pouring it into tubs on tipping waggons of about ten tons capacity; or it may be removed in ladle waggons similar to those for liquid metal. The waggons are very often of standard wheel gauge. A number of these have been built by the Junkerather Company.

Owing to the certainty with which the phosphorus, the heat-agent in the basic process, can be introduced into the pig iron, the practice of conveying the iron in the liquid state from the blast-furnace to the steelworks has been everywhere adopted where the local conditions were favourable. Mixers with tilting arrangements, which contain up to 250 tons of metal, are also installed at almost all these works. Among many other advantages attending the transport of liquid metal, not the least is the great economy in labour gained thereby. Under these altered conditions the term "pig iron," familiar also among German iron-workers, certainly appears to lose its significance. Casting-machines have not been adopted in Germany, for the reason that almost all the iron is sold according to analysis, or is at least carefully sorted.

In recent years the exterior of the blast-furnace has undergone considerable modification. The heavy cast-iron columns supporting the cast-iron bearer plate are now seldom used, nor is the framework, consisting mainly of four corner columns carrying the top charging platform. In the newer installations eight columns are arranged round the furnace-body, standing upon the foundation below the free-standing hearth. These are carried up to the charging platform, and the wrought-iron bearer plate is supported on brackets projecting from them, also the platform giving access to the tap-hole and the tuyeres. The casing of the hearth and boshes is constructed of strong rivetted plates, though it often occurs that the boshes are constructed with cooling rings and wrought-iron hoops. The furnace-body is held together by strong hoops. The expansion of the furnace-body is provided for by means of stuffing boxes beneath the charging platform. At some works the furnaces are built of bricks of small dimensions, laid with cement. Carbon bricks are also much used. Mr. Burgers, of Schalke, has constructed a furnace at the Vulcan Works, the body and bosh of which consist of cast iron, lined with fire-brick. This furnace has been nearly three years in operation, and the working has been perfect, even though he has blown hot-working iron alloys, such as ferro-silicon. A model of this furnace is shown in the Exhibition. At the Hoerde Works, Mr. Von Vloten has placed at the tuyere level a ring formed of water-cooled bronze wind boxes, which rests on a heavy ring-casting.

The dimensions of the newer blast-furnaces in the coal district and the minette region vary in the following degree :—

	Metres.
Height - - -	22 to 25 (72 to 82 feet).
Diameter of throat -	4 to 5 (13 to 16½ feet).
Diameter at the bosh -	6 to 7 (19½ to 23 feet).
Diameter of the hearth	3·5 to 4·5 (11½ to 18 feet).

DAILY OUTPUT OF THE GERMAN BLAST-FURNACES.

As regards the daily output of the German blast-furnaces, this amounts to about 200 tons per furnace per day. In the minette district it averages somewhat less and in the coal district a little more. Much higher productions are achieved in individual cases. An inquiry addressed to the Deutscher Kaiser Company elicited the reply that in 1902 the daily output of one furnace had been 518 tons, while the combined output of four other furnaces was 1,661 tons, or 415 tons per furnace. The extraction from the ore mixed with flax charged was 42 per cent.

The employment of labour at the blast-furnaces varies exceedingly, so that comparative data are scarcely obtainable. To add to the difficulty, the particulars submitted by the works frequently include the industries connected with iron-making, such as coke-making, brick factories, etc. Again, those works which manufacture every kind of iron naturally have to stock ores of all kinds on a large scale, which increases the cost of transport of raw material. Finally, those blast-works which treat the pig iron in the liquid state can economise considerably in labour.

Still, the figures for some of the works may be of interest :—

Jan. 1 to June 30, 1902.	Production.	Number of Workmen.	Output per man per year.
	Tons.		Tons.
Deutscher Kaiser Co....	208,651	980	419
Hoerde Verein	255,720	685	373

The following data were also given by the kindness of the Hoerde Verein :—

BLAST FURNACE WORKS AT HOERDE.

Year.	Production of Iron.	No. of Workmen Employed at the Blast-Furnaces.
	Tons.	
1880-81	77,276	602
1881-82	82,204	595
1882-83	19,048	583
1883-84	94,078	659
1884-85	99,442	558
1885-86	106,468	549
1886-87	91,256	574
1887-88	131,633	513
1888-89	121,898	470
1889-90	134,785	478
1890-91	122,618	478
1891-92	147,500	497
1892-93	146,570	491
1893-94	178,762	517
1894-95	181,241	565
1895-96	215,835	583
1896-97	218,640	581
1897-98	239,990	694
1898-99	250,956	645
1899-1900	274,099	772
1900-01	279,444	800
1901-02	255,720	685

The maximum output at any one furnace at Hoerde was 238 tons.

PROGRESS IN STEELWORKS PRACTICE IN GERMANY SINCE 1880.

Mr. R. M. Daelen, of Düsseldorf, read a valuable paper on the progress of the steel industry in Germany, before the Iron and Steel Institute, giving in as brief a space as possible, an account of the recent progress and more important improvements which have been effected in the production of steel on a large scale.

Since the last occasion on which the Iron and Steel Institute visited Germany in the year 1880, a notable development has taken place in the production of steel in this country, and to-day again, as formerly, the Industrial Exhibition of the Rhine Provinces and Westphalia affords a fitting opportunity for taking note of the progress which has been achieved in recent years.

METHODS IN USE FOR THE TREATMENT OF STEEL.

After a brief review of the general situation in the German iron industry the author says :—

Returning now to the methods in use for the further treatment of steel, it will be found that the older-established works have for the most part retained the well-known system of casting ingots, consisting of a hot-metal ladle carried either on a slewing or travelling crane, and successively placed above the stationary ingot-moulds. On the other hand, only a few of the more modern works have adopted the reverse method of drawing the ingot-moulds along beneath a stationary ladle, combined with which process is also the forcing out of the ingots from their moulds by mechanical means.

The latter method does not permit of filling several moulds at once by bottom pouring, and its adoption has extended according to the ability to roll rough ingots at one heat into finished products such as wire, rods, small sections and plates, which formerly had to be reheated after one rolling. By this means in many works the blooming rolls are dispensed with, an arrangement, however, which is only profitable where the daily production is a perfectly regular one, such as is usual in the very large basic Bessemer steel-works.

It is the special aim in these works to roll down the ingot at the original heat, that is, by the use of the Gjers non-fired soaking-pits. The Gutehoffnungshütte first developed this system, and at these works the ingots, after passing through the blooming-mill, are rolled without any reheating into sections, rails, and sleepers in a three-high mill. The results were so successful that other works have now followed the same plan. The steel manufactured by the basic process can be removed from the moulds, and plunged in the plain soaking-pits sooner than that blown in acid-lined converters, a fact which tells in favour of the system. It is also necessary to provide a means of transferring the ingot from the blooming rolls to the finishing rolls as rapidly as possible. When this cannot be done, as in the case of such works which have no blooming-mill, soaking-pits, fired on the Siemens regenerative principle, are employed, though the disadvantage then arises that the entire charge is heated at one time, and that the subsequent introduction of cold ingots has the undesirable effect of cooling those still remaining in the pits. To obviate this difficulty many works employ in connection with the soaking-pits the rolling furnace of Helmholtz, of Ruhrort, with a very long hearth and fired at one end, in which the ingots are carried forward to meet the flames. But this apparatus necessitates too much hand labour, besides being productive of considerable waste of metal, and on this account, since the prevailing requirement is a uniform method which ensures the heating of cold ingots and the preservation of heat in the hot ingots, the American continuous reheating furnace with pushing gear has latterly been introduced in several places, the results of which are more satisfactory.

The use of electric motors for driving rolling-mills is at present very limited, and will probably only be adopted in cases where the electricity is generated more cheaply than is possible by steam power. It is, however, now very largely used for driving the auxiliary machinery about the mills, and it is generally regarded as certain that in modern works it will entirely supersede the low-pressure hydraulic machinery which formerly was in common use. Still, it must be admitted that the same precision of movement in cranes and hoisting gear is certainly not attainable by electric means, and for this reason many practical engineers of iron works still have a preference for low-pressure hydraulic power, especially as the machinery which gives it effect is constantly being improved.

In general, it may be observed that the German steel-works and rolling-mills are compelled to bestow strict attention on their plant and their practice in order to meet the requirements of their market—these are of a diverse nature, and orders for one quality or form of product are by no means of the same magnitude here as is often the case in the same industry in other countries. In arranging the buildings and machinery, the chief aim to keep in view is accordingly not only a large daily output and the saving of labour, but it consists rather in devising how to do work at remunerative rates even with apparatus and machines of medium productive capacity, and with frequent changes in the kind of material supplied. If on this account the German works are less imposing as compared with modern installations abroad, we can console ourselves with the reflection that circumstances must be adapted to meet conditions, and that limits can be set to all competition, however much this may be feared.

THE POSSIBILITIES OF "WIRELESS" TELEGRAPHY.

IN the *Monthly Review* for September Mr. Charles Bright, C.E., F.R.S.E., deals with the above subject. His article, he says, has a double object: First, to show that "wireless" telegraphy cannot at present be regarded as a serious competitor with cable telegraphy on a commercial basis; and, secondly, to point to the varied possibilities of ætheric, or so-called "wireless" telegraphy, even in the form we now know it:—

The somewhat dramatic policy pursued by Mr. Marconi has one advantage, if no other. It arouses attention to scientific possibilities—even if of the future—in a direction that the ordinary dividend-seeker of this country has not, as a rule, shown himself capable of appreciating or of interesting himself in. On the other hand, there is a certain irony attached to Mr. Marconi's selection of the three dots representing the letter S for his Atlantic experiments; for, apart from simplicity, it is just three such S's that spell sureness, speed, and secrecy—the three factors, which, at present, prevent ætheric telegraphy seriously jeopardising submarine cable enterprise. By way of substantiating the latter statement, we must turn from the pre-arranged Atlantic S signals (not messages), about which we have no details, to Mr. Marconi's best attainments in actual and accurate messages between ships and between ship and shore, at a maximum distance of about 250 miles, under more or less favourable conditions. This, be it noted, is a very different sort of thing to surmounting the earth's curvature across the Atlantic, corresponding to a mountain over 100 miles high. The difference should, moreover, be realised between catching a few more or less pre-arranged signals across the Atlantic, and that of an Atlantic cable system working continuously at a duplex, automatic speed of nearly 100 words a minute, 90 per cent. of which are cipher and code messages.

The Marconi system, which has, so far, done most of the practical work in wireless telegraphy, is fundamentally based on the coherer receiving relay, which is an excessively sensitive and delicate instrument. Whilst having obvious advantages, an apparatus of this character is, of necessity, extremely liable to get out of adjustment. For this reason it is somewhat unreliable and apt to give confused and false signals. The Marconi coherer of 1896 is, moreover, more or less readily affected by its surroundings and general conditions, including atmospheric and other natural and electric disturbances. Thus, Mr. Marconi's Atlantic experiences have been sometimes attributed to this cause alone—atmospheric "strays," and the question has naturally been raised as to how the apparatus would behave in the presence of a lightning storm. To these objections no very satisfactory answer is forthcoming at present; and until further particulars—indeed, proofs—are available, it is not unnatural that impartial authorities should question the likelihood of Marconi's system becoming a practical commercial telegraph for bridging long distances.

Mr. Bright then proceeds to deal with the important consideration of the secrecy of "wireless" messages :—

Perhaps the most important question in connection with the practical advancement of wireless telegraphy just now is to what extent syntony can be usefully applied for guarding against foreign influences in the form of interruptions, "eavesdropping," and errors due to natural causes or otherwise. The mutilation of messages by an intervening party was forcibly illustrated during the famous *Shamrock II.* and *Columbia* yacht race of last year, as well as on other occasions; but it is believed that Mr. Marconi has effected considerable improvements in tuning the period of oscillation in his recent receiver, and his Lizard Station is said now to be more or less unaffected by the large electric power-house seven miles off. It would appear, however, that, without a monopoly of the atmosphere or an absolutely perfect screening no "wireless" apparatus could be really free from surrounding conditions and the effect of other instruments to which no limit can be placed. For this reason it has been doubted (1) whether there is any money in the invention as a system of commercial telegraphy; and (2) whether it is likely to prove useful on a large scale for strategic purposes. There seems to be no question about the possibility of "tapping" a message at will—at any rate, with an untuned receiver. On the other hand, there appears to be no absolutely sure means as yet of preventing a third party (or climatic conditions) effecting such interruption. Whilst it is perfectly true that by the use of a code the secrecy of messages is to a great extent assured, it may reasonably be doubted whether ætheric telegraphy—as yet, at any rate—is sufficiently reliable and accurate for code or cipher work. To render wireless telegraphy a really practical business and an efficient means of "All-British" communication in times of war as in peace, the following conditions will require to be attained: (1) The apparatus must be capable of being "tuned" to a certain pitch—*i.e.*, a certain number of vibrations in a given time—in such a way that the message is strictly confined to that particular receiver; (2) On the other hand, to meet naval requirements, the apparatus on board a warship should be capable of picking up the tune of any of the enemy's ships; (3) Yet again, means will have to be found for overcoming the possibility of a message being rendered a mere jumble by the intervention of a third party, or of the elements.

Discussing the practical uses to which "wireless" telegraphy may be put to in the future, he remarks :—

From a strategic point of view, as well as from a general maritime and life-saving standpoint, Great Britain and Ireland should be provided with a complete system of telegraphic communication round the entire coast, putting every coast station into connection with various inland centres and military stations. It is a piece of work which would be most effectively accomplished by wireless methods in preference to overhead lines, assuming for the moment that the strategic requirements set forth in this article could be met. For maintenance reasons, too, cables are inefficient here, owing to abrasion against rocks, strong tides, kinks, etc. Wireless telegraphy is admirably suited for lightship and lighthouse communication with the shore, to assist navigation in avoiding collisions due to darkness and fog, and also for the mercantile marine service, for vessels in distress, etc.; indeed, in any case where cables cannot be usefully turned to account, or where mere signalling, rather than high speed commercial messages, is the order of the day. May it not be asked—in the public interest, as well as in the cause of science—who is to blame for the fact that so little really useful and practical work of this description has been accomplished? Surely it cannot be the Government telegraph monopoly that blocks progress? The latter cannot, at any rate, stand in the way of wireless communications on the high seas; and with so persevering a worker as Mr. Marconi we may, indeed, look forward to the days when the fact of setting forth on a voyage need not necessarily imply being cut off from communication with the rest of the world: thus those who aspire to having news continually served up to them, even when at sea, may yet live to see their ambitions realised in a really practical way.

In conclusion, the writer points out that the imperfections of the system are likely to prevent it from becoming a serious rival to the cable companies :—

That the wireless system has come to stay is fairly obvious; but what its possibilities may reach we cannot at present foretell. Its inferiority, however, to telegraphy by cables is, at present, as marked as would be the delivery of our letters on the pavement—to be picked up by anyone—instead of in the letter-box. Cable shareholders may, therefore, take comfort in feeling that the day has not yet come—neither can we as yet foresee that it will come—when copper wires, gutta-percha coverings, and iron sheathings will be relegated to the museum of antiquities. On the other hand, it seems clear that wireless telegraphy will have an awakening effect as to our telegraphic needs, just as the electric light, by raising the standard of light required by the public, has enabled us to rejoice in the incandescent gas mantle in cases where the still better illumination obtained from electricity is conspicuous by its absence.

REVIEW OF LEADING CONTINENTAL PAPERS.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of the Continent.

WINDING FROM GREAT DEPTHS.

ENGINES for winding from great depths are naturally very powerful, their cylinders being always near upon 1 metre (3 ft. 3⅜ in.) in diameter, with a stroke of double that figure; but compound engines are still the exception. The steam distribution is generally effected by lifting valves, with expansion variable by the governor, but with possibility of the engineman suppressing the expansion, while there are often two brake pulleys. Rescue or emergency engines are the rule both in Belgium and Germany. Sometimes, as in Belgium, they are constituted by a simple capstan; but in others, as in Westphalia, where the output is enormous, they become veritable winding engines, generally less powerful, but sometimes, again, exactly like the main engines. Appliances for the prevention of overwinding, almost unknown in Belgium, are common in Germany. Sometimes the Haniel and Lueg disengaging hook, resembling the English hook invented by Stephen Humble, is completed by a brake that comes into action if the cage should be drawn up to the pulleys; and in other cases the appliances shut off steam and put on a brake when the cage rises above the pit bank, after the manner of the Reumaux safety apparatus.

WINDING DRUMS.

Although the difficulties connected with great depth of working are, as yet, scarcely felt in Westphalia, at some mines where little over 500 metres (273 fathoms) is reached, the surface works have been laid out for winding from double that depth, in which case the engines are very large and complicated. Thanks to the lightness of the Koepe arrangement, that system is relied upon for winding from depths such as 1,200 metres (656 fathoms) and upwards; but for those at present attained cylindrical drums with balance ropes, moving freely in the shaft, or spiraloid compensating drums, are used, while timber guides for the shafts are retained in Germany, though steel rail guides are common in Belgium.

SPEEDS OF WINDING.

For winding coal the speed rarely exceeds 20 metres (65½ ft.) per second, while the mean is 13 metres (42½ ft.); and for winding men the speed varies from 4 metres (14 ft.) to 6 metres (19½ ft.) per second. Speed indicators, and, indeed, speed recorders, are fitted to the winding engines of nearly all the shafts in Germany visited by M. Deverne, chief engineer of the Douchy Colliery, in the North of France, who recorded his observations for the benefit of the *Société de l'Industrie Minérale*, arriving at the following conclusions: Cases of winding from a great depth occur nearly everywhere with the various means available on the spot; but it is evident that, as the depth increases, if a large output is to be maintained, steel wire must supersede Manila fibre for the ropes, while in many cases a limit will be imposed rather by the deposit itself and the difficulties of working it than by the winding gear proper.

RECENT PROGRESS IN GOLD METALLURGY.

FEW scientific discoveries have had such great influence on the mining industry as that exerted on gold mining by the cyanide process, which has permitted of turning to account a great many deposits that were previously regarded as refractory because they resisted amalgamation. On cyanisation being applied to the residues of amalgamation, however, it was soon seen that, if the sandy portion of these residues was easily treated owing to permeability of the sand, the slimes offered resistance to penetration by the cyanide solutions, as also to air circulation, without which these solutions cannot dissolve gold; and this led to the residues being classed as tailings proper and as slimes. Moreover, the nature of the residues becomes modified as the mines are worked deeper, passing from the oxidised zone of the outcrops to the pyritous region underground; and it was on this account that the pyritous concentrates, of far greater richness than the tailings which yield them, were separated by various concentration appliances.

The conditions and present practice in the Transvaal and in Western Australia, with particulars as to yield and cost of extraction, were detailed to the *Société de l'Industrie Minérale* by M. H. Kuss, Ingénieur-en-chef des Mines, who passed in review successively the treatment of slimes by filter-presses, the treatment of sulpho-telluric ores, the direct treatment of raw ore by the Diehl process, and also by simple cyanisation, as well as by roasting and porphyrisation, arriving at the following conclusions:—

TREATMENT OF SULPHO-TELLURIC AURIFEROUS ORES.

The problem of treating Kalgoorlie sulpho-telluric auriferous ores has been solved quite satisfactorily; and a choice of three methods is now afforded, as under.

1. The amalgamation, porphyrisation and cyanisation of the raw ore, yielding about 85 or 86 per cent. for an expense of 15s. per ton.
2. Porphyrisation with bromo-cyanisation, by the Diehl process, yielding 90 per cent. for a cost of 25s. per ton.
3. Roasting, followed by porphyrisation, amalgamation, and cyanisation, also yielding 90 per cent. for a cost varying from 23s. to 27s.

Taking into account preparatory works, the ore costs on an average 20s. per ton, while general expenses vary from 3s. to 5s. Works for treating 80,000 tons per annum cost about £160,000, so that their liquidation in four years, which is reasonable, gives 10s. per ton per annum, bringing up the total expense to within £3 per ton.

The cost of extracting and treating a ton may come down to £2 10s., if roasting and the increased yield it affords be dispensed with, and even with roasting if liquidation be not taken into account; or to £2 for works treating the raw ore by simple cyanisation. If a yield of 90 per cent. in the former and 85 per cent. in the latter case be admitted, it is easy to see that the corresponding limit contents of the ore to be treated without loss will be 14 and 12 dwts. respectively per ton. Cyanisation of the raw ore would appear advantageous for ores containing from 12 to 25, or even 30 dwts. per ton; but for those of a higher content roasting would have the advantage.

PURIFICATION AND UTILISATION OF BLAST-FURNACE GAS.

NOW that the use of blast-furnace gas for motive power forms the subject of so many fresh investigations, it must not be forgotten that the practical utilisation of this gas is due in a great measure to Frenchmen. So early as 1814, Aubertot, an ironmaster at Vierzon, employed the gas of his blast-furnaces for heating purposes. Between 1835 and 1845 this gas was used for raising steam; but the boilers were at the level of the furnace mouth, which was left open, the gas being drawn under the grate by the chimney draught. About 1840, and until 1855, from 25 to 40 stoves thus fired were used in the Ardennes for torrefying green wood to serve as fuel. About the same time Ebelmen studied the utilisation of gas from blast-furnaces, coke-ovens, cupolas, etc., and also, in collaboration with Sire, made experiments in puddling with the gas of charcoal-fired furnaces. A little later M. Laurens, M. Thomas and M. Robin designed gas-burners for firing boilers, hot-air stoves and arrangements for closing blast-furnaces; and in 1857 an Ardennes ironmaster interposed a fan between the furnace mouth on the one hand and the boilers and stoves on the other, which permitted him to work with the furnace mouth open. In 1869 M. de Langlade employed at five or six ironworks a scrubber, invented by the Swedish engineer Lundin, for purifying the blast-furnace gas with which iron was puddled and the puddle-bars reheated. In 1888 M. Lespinats put up at the Neuves-Maisons blast-furnaces, gas-purifiers, resembling greatly those of Bethlehem, U.S., and which have given good results. Finally, in 1893, M. C. Cavallier, general manager of the Pont-à-Mousson ironworks, put up a dry purifier, made of large rectangular cases, filled with iron "straw," on which the greater part of the dust was deposited, this being the best arrangement when the dry method is employed.

M. LENCAUCHEZ'S PAPER.

It is with these considerations that M. Alexandre Lencauchez opened a paper on this subject of the day to the *Société de l'Industrie Minérale*, afterwards proceeding to trace successive improvements in France and other countries, dealing with fans, scrubbers and purifiers, the employment of blast-furnace gas and gas engines, while summing up with (in substance) the following observations: It may be said that the purification of blast-furnace gas is now possible, and that the use of this gas for firing boilers, hot-air stoves, refinery and heating furnaces, etc., has become thoroughly practical, because purification permits the use of regulators which maintain the combustion under constant draught and pressure, so that the useful effect can be tripled.

The author also expresses his great satisfaction at having, towards the close of his career, found a practical solution of this interesting problem, having on November 12th, 1900, written to the manager of the Micheville Steelworks that a considerable injection of water under pressure at both inlets of one of the two fans used there would probably afford excellent means of purification, and having on January 10th, 1901, patented an arrangement of multiple fan combined with water injection.

BLAST-FURNACE GAS FOR MOTORS.

As regards the motors utilising blast-furnace and other gases, he considers that there still remains much to be done, chiefly for those of 500 to 2,000 h.p. and upwards, for instance, making them work with boiling water for the sake of economy, while there would also be an advantage in substituting 2-period for 4-period motors as regards utilisation of the cylinders. Two-period engines also have the great advantage of suppressing the exhaust valve; and they permit of arranging the gas and secondary air valves in chests not exposed to the action of the flames, thus avoiding deformation of the parts. They are probably the precursors of combustion motors which, by suppressing the disadvantages of explosion, will give gas engines all the suppleness and elasticity of the best steam engines, capable of working at higher temperatures, and consequently losing far less power through the cooling currents of the jackets. In conclusion, for a plant utilising blast-furnace gas to afford absolute industrial security, the gas must be taken off at a pressure slightly below that of the atmosphere; and such pressure must be ensured automatically, because otherwise there will be the danger of violent explosions.

ELECTROMETERS—THE SCHATTNER METER.

MOST electrometers—or those, at any rate, that have come into practical use—may be classed as (1) motor meters, (2) clock meters, or (3) electrolysis meters, which were described in the following terms by Messieurs Georges and Paul Deschamps for the *Hainaut Engineers' Society*:—

MOTOR METERS,

of whatever type they be, must satisfy certain conditions. The motor must work with very slight fall of potential, and absorb but little power. Strong and compact, it must run at a speed always proportionate to the current. Friction must be either insignificant or perfectly balanced. An arrangement is generally adopted in which a certain amount of current constantly passes without being registered; but the realisation of all these conditions leads to such complication as to render it practically impossible to make such a meter at a moderate price.

CLOCK METERS.

Formerly clock meters had to be wound up; but now electric clocks are employed. Two perfectly distinct principles are applied to the construction of these meters. Either the current exerts an action on the clock's speed; or the clock has nothing to do but exactly determine the intervals at which special mechanism measures and registers the intensity of the current. Whatever be the principle adopted, however, its application requires complicated mechanism that can work exactly for a long period, while these meters are often cumbersome; and therefore they, too, cannot be made efficient for a moderate price.

ELECTROLYSIS METERS.

For securing this last-named desideratum complicated mechanism must be given up, which is possible by the use of electrolysis. The weight of matter deposited in an electrolytic jar is strictly proportional to the quantity of current that has traversed it. This principle has long been utilised in the construction of meters for continuous-current installations; but in practice serious difficulties are encountered, it being specially necessary to avoid too great a loss of voltage.

THE SCHATTNER ELECTROMETER

also depends upon electrolysis, while avoiding, however, the chief defects mentioned above. Sulphate of copper and copper electrodes are employed; and the indicator is a scale beam, which registers the weight of metal abstracted from the anode suspended from its end. There is only, in this electrolytic action, transport of copper between the electrodes, the solution undergoing no modification on that account, so that the loss of voltage is reduced to a minimum. The surfaces of the electrodes are very large, and the density of the current slight, so that a regular deposit is obtained.

ACCUMULATOR-CHARGING METERS.

In many electrical installations placed under the charge of inexperienced persons the accumulators are often damaged through deficient charge or over-charge; and to meet this difficulty a special type of meter has been made, that constantly shows whether a just measure has been observed in charging and discharging. Such a meter, which must evidently permit of a greater current during the charge than during the discharge, consists of an apparatus like an ordinary meter combined with an automatic interrupter that shunts a known and defined fraction of the current during the charge, so that as much copper is taken off the anode during the discharge as is deposited upon it during the charge, and the balance is in equilibrium when the charge régime is normal. With this apparatus, therefore, an inexperienced person can readily ascertain if he is charging, and to what extent, a set of accumulators.

ADVANTAGES OF THE SCHATTNER ELECTROMETER.

These meters are inexpensive, owing to their simple construction; and their maintenance is cheap and easy, owing to the absence of complicated mechanism. The copper plate, that costs 4s., need only be renewed after a consumption of 600 to 1,000 k.w.-hours. The loss of current occasioned by this meter is very slight—0·7 per cent. of the voltage when in action, but nothing at all when out of action; and it registers correctly to less than one-tenth of an ampère.

CENTRAL STEAM CONDENSATION.

THE laying down of central condensation plant is a matter of serious difficulty, especially when the volume of exhaust steam is very variable, as in the case of mines, owing to the intermittent working of the winding engines. It is not therefore surprising that the problem long remained without satisfactory solution; but in Germany the tendency is increasing, at works where there are a great many steam engines, to lead all the exhaust steam to a single condenser, while a cooling apparatus is generally added, which permits of using the same water over and over again. Thus remarks M. Henri Dechamps in his review of the mining machinery at the Düsseldorf Exhibition for the *Liége Engineers' Association;* and he continues that, according to the conditions of each case, the system of injection or surface condensation is employed. In the latter, the steam may be made to pass through several superposed series of pipes sprinkled with water falling in a cascade; or the pipes may be immersed in a basin traversed by a water-current. Again, the usual surface-condenser arrangement may be adopted — a group of tubes inside a cylindrical casing between two tube-plates, and traversed by a stream of cooling water, the steam to be condensed being led into the space round the tubes.

THE WEISS SYSTEM,

represented by G. Brinckman and Co., of Witten-on-the-Ruhr, is characterised by its adoption of the counter-current principle. The cooling water is admitted at one end of the plant, and the steam to be condensed at the other, the two currents passing in opposite directions, and their relative speed being equal to the sum of their absolute speeds. Moreover, the portions already cooled of the steam to be condensed encounter the coldest water; and as the latter becomes heated it comes into contact with steam of higher temperature. The air and the hot water are drawn off by two distinct appliances, the former in the smallest possible volume, *i.e.*, with a minimum expenditure of power. The plant comprises a vertical condenser, at the top of a pipe, 10 metres (33 feet) high, the lower end of which dips in a basin, while the general pipe leading the exhaust steam gives into the bottom of the condenser. On the contrary, the water-injection pipe terminates near the cover; and the cooling water is raised by a pump, not to the condenser, but to a tank some distance from it, though not too far for the water to accomplish the rest of its travel, owing to suction caused by the vacuum. The water then descends, meeting the steam, being divided into very thin sheets by baffle-plates; and the mixture which it forms with the condensed steam flows into the tank above which the condenser is placed, owing to the difference of level, that corresponds with an atmosphere of pressure. To the Weiss condenser is annexed a

BLASBERG COOLING APPARATUS,

which consists of a rectangular timber chimney, having at the bottom a Horden refrigerator, made of superposed slats covered with small pieces of basalt. A special pump raises the hot water from the condenser, which water is distributed over the whole surface of the refrigerator, being sub-divided by the pieces of stone into small drops, while the air drawn by the chimney draught passes across interstices in the stone beds.

BALCKE & CO.'S CONDENSATION PLANTS

are always on the counter-current system, whether a surface or an injection condenser be employed; and in the latter case, when local circumstances permit, the condenser is placed at a sufficient height above the discharge channel to render a hot-water pump unnecessary.

In the former case the exhaust steam passes from the collector to the oil-separator, generally cylindrical with vertical axis, containing three parallel vertical plates, punched with holes alternately at top and bottom so as to form baffles; and the oil collecting at the bottom is withdrawn by a special pump. The steam then continues to the surface condenser, supplied with cooling water by a circulating pump; and the air drawn along with the steam is taken off by a dry-air pump through a pipe starting from the highest part of the condenser, and provided with a small purifier for freeing it from any moisture, the bottom of this purifier being put in communication with the hot-water pump. All the pumps are worked off a two-throw crankshaft from a steam engine. This firm claims to have invented chimney coolers, the chief advantages of which are that their efficiency is independent of atmospheric movement, and that the dew or vapours are given off from them at such a height as to constitute no nuisance to the neighbourhood.

GOLD MINING AND GOLD-STEALING IN SIBERIA.

THE Russian review *Russkoe Bogatstvo* for September (August 30th), contains a very interesting article by M. Paul Bieletski on the methods of gold-mining practised in Siberia. M. Bieletski argues that the formalities and red-tape which at present make prospecting in Siberia almost impossible, should be replaced by a simpler system. At present prospectors have to undergo such a number of formalities, both before prospecting and after discovering gold, that only those with capital to risk, and those who evade the law, have a chance of carrying on the industry at a profit. Before setting out at all, the prospector has to obtain a stamped certificate giving him authority to prospect. This certificate he has to present at the local Government office, with his passport and a police certificate. If he wishes to do this quickly he must appear personally at the Mining Department. But this only begins the necessary formalities. When his party is formed, he must notify the district police office as to where he proposes to prospect, lodge a further copy of his certificate, and give full particulars as to names, passports, etc., of every member of his party. Before prospecting for gold he must mark off the five versts of river, or four square versts of land, where he proposes to search. But this gives him only a right to search for gold, and no right to work it. If he discovers any gold whatsoever, he is obliged to stop working, and even return the gold to the ground, until he gets the necessary authority to work it. This requires further reference to the nearest police office, sometimes a thousand miles away, and long delays, payments, and more detailed marking off of claims. This marking off must be done by a government official, who having travelled a thousand miles, must be lodged at the prospector's expense. Finally, every dwt. of gold must be registered in books. It is only after providing for all these formalities that the actual working of the deposits can be commenced But when work is begun it may very well happen that the deposits are so poor as not to be worth working; in such a case the prospector loses his time and money, and before attempting to work another claim he must repeat the formalities, perhaps only to meet with another disappointment.

The result of all this red-tape is that a very large proportion of Siberian gold is got by evasion of the law. The prospectors prefer to employ *khistchniki*, or uncertificated miners, mostly belonging to the criminal class, from whom they buy gold at much below its value. The certificated miners and prospectors complain much of the depredations of these *khistchniki*, but in reality they profit by their labour, as it is much cheaper to buy illegally worked gold than to work it under the present conditions. The Government, by means of Cossacks and police, carries on a continuous war with the uncertificated miners, a conflict sometimes attaining the dignity of pitched battles, but without result. The *khistchniki* form the advance guard of most regular prospecting parties, and owing to the lack of information as to the geological conformation of the gold districts, they as often as not discover gold-bearing land in shorter time than the regular prospectors. "The discovery of gold," says M. Bieletski, "is, to a great extent a matter of chance, the ignorant workman often being as successful as the skilled geologist." The prospectors therefore often make large fortunes by buying the "rights" to gold-bearing land discovered by vagabonds and escaped convicts. In conclusion, M. Bieletski argues that all the formalities which must now be undergone before actual working should be done away with, and that the right of prospecting should be open to all.

RUSSIAN SHIPPING AND CANAL PROJECTS.

THE project for constructing a deep-water port at Kertsch has been condemned by the Taganrog Committee of Trade and Manufactures, on the ground that, if Kertsch were selected as a central port for ocean-going ships, there would be a general decline of the Azov ports, resulting in serious losses for the rival ports of Taganrog, Rostoff, Mariupol, and Berdiansk.

The *Odessa News* urges the necessity of joining the White, Black, and Baltic Seas by means of canals, maintaining that, under no circumstances, should the work be allowed to pass into the hands of a foreign company. The *News* lauds the project as one "incomparably more useful for the Empire and people than the new railway across the Asiatic Continent."

The *Odessa News* gives particulars of a newly-formed Italian company which has entered into negotiations with the Russian Volunteer Fleet for the opening of regular communication by means of large steamers between the Black Sea and New York, the volunteer steamers to carry on freight and passenger traffic between Odessa and Naples, and to carry Italian emigrants from Naples to the United States. It is proposed at first to devote two volunteer steamers of the *Petersburg* and *Orel* class to this traffic. This project has been accepted favourably by the Volunteer Fleet, as the administration of the fleet had already been considering the advisability of extending the area of their operations.

LINE FROM MOSCOW TO BE RELAID.

The Russian Minister of Ways of Communication has raised the question of increasing the speed of the express trains from Moscow to Western Europe to a rate of 65 versts an hour. The directorate of the Moscow-Brest Railway, after considering the question, replied that with the present permanent way the present speed of 50 versts an hour cannot even be maintained, and that the whole line must be relaid with rails of the officially recognised weight of 28½ lbs. to the foot. This change is to be completed within four years, at a cost of 20,000,000 roubles. Meantime, the speed of the express trains is to be reduced to 44 versts an hour, increasing the journey between Moscow and Brest by 1¾ hours.

NEW CIRCULAR RAILWAY AT MOSCOW.

In Moscow the preparatory works for the new City Circular Railway, the plan of which was approved by the Emperor in March, are being pushed forward. The surveys are completed, and M. Rashevsky, the engineer in charge, proposes to begin construction this year. The estimates for the railway amount to 40,000,000 roubles, and it is expected the new line will be opened in 1905. In view of the fact that the circular railway will supply only the suburbs, while the centre of the city will be cut off as before, M. Rashevsky has put forward a project for the construction of a municipal diametrical line on the model of Buda-Pesth city railway. The cost of such a railway in Moscow is estimated at 25,000,000 roubles.

RUSSIAN RAILWAY PROJECT REVIVED.

THE St. Petersburg *Courier* announces that the old Russian project of building a railway from Central Asia to Siberia is on the point of realisation. A private company of Russian and foreign capitalists under the leadership of Mr. S. I. Mamontof has been formed with the approval of the government. The line will start from the town of Turkestan, intersect the Siberian Railway near Tomsk, and be extended to the north to a point not yet determined. The railway is to supply the needs of the rich grain-growing districts in the south of Tomsk Government, Biisk, Barnaul, Altai, and the Semipalatinsk Oblast. Trade between Tomsk and Northern Siberia is to be carried on by steamers on the Tom and Obi, but in view of the defects of the Gulf of Obi it is proposed to build a line from Obdorsk, near the mouth of the river, to some more favourable port on the Arctic Ocean. These constructions will complete communication between Central Asia and the Arctic Ocean. The estimated cost is 150,000,000 roubles, or half the first estimated cost of the Great Siberian Railway.

SOME BOOKS OF THE MONTH.

"A HISTORY OF WIRELESS TELEGRAPHY."

Including some bare-wire proposals for subaqueous telegraphs. By J. J. Fahie, M.Inst.E.E. William Blackwood and Sons. 348 pp. 6s.

IN this interesting work, which now appears in its third edition, Mr. J. J. Fahie has afforded the electrical student much valuable information. The experiments of those inventors who first conceived and carried into practice the idea of space telegraphy are described, and the achievements of modern inventors carefully detailed. Events move rapidly in the electrical world, and thus it was found that the first edition of this history, in view of recent researches, required to be brought more into line with modern developments. To Mr. Fahie's work, therefore, was added a survey of the advances made in "wireless" telegraphy up to the beginning of 1901, when the second edition appeared. In the frontispiece are grouped the portraits of those whom the author aptly terms "the Arch-builders of Wireless Telegraphy."

At the top stands Oersted (Denmark), who first showed the connection between electricity and magnetism. Then follow in order of time Ampère (France), Faraday (England), and Henry (America), who explained and extended the principles of the new science of electro-magnetism. Then come Clerk-Maxwell (England) and Hertz (Germany), who showed the relation between electricity and light, the one theoretically, and the other by actual demonstration. These are followed by Branly (France), Lodge (England), and Righi (Italy), whose discoveries have made possible the invention of Marconi. The last three are portraits of Preece and Willoughby Smith (England), and Marconi (Italy), who divide between them the honour of establishing the first practical lines of wireless telegraphy—each typical of a different order.

As has been pointed out in recent articles on this subject, there exists much popular misconception as to who was the "real inventor" of "wireless" telegraphy, and this Mr. Fahie's book has done and will do much to remedy. Ample recognition is given to the significance and importance of the labours of Sir William Preece and Mr. Willoughby Smith, and the interesting record of their researches forms a fitting preface to a description of Signor Marconi's world famous experiments. In the appendices we have various papers and reports of lectures by Sir Oliver Lodge (on the relation between electricity and light, before and after Hertz), Professor Henry (on high-pressure electricity being confined to the surface of conducting bodies, and, modern views with respect to the nature of electric currents), and Professor Edouard Branly (on variations of conductivity under electrical influence), with a description of the remarkable researches of Professor Hughes, F.R.S., in electric waves and their application to "wireless" telegraphy, which he conducted during the years 1879-1886. These are followed by a reprint of Signor Marconi's patent, with plans, which should prove of special interest to readers of the article on Signor Marconi's inventions appearing in this issue. Various diagrams help to elucidate the text, and an exhaustive index renders the volume valuable as a book of reference. The work is dedicated to Sir William H. Preece, K.C.B., F.R.S., "as a slight token of esteem and friendship, and in acknowledgment of many kindnesses extending over many years."

"MODERN IRON FOUNDRY PRACTICE"—PART I.

By George R. Bale, A.M.Inst.C.E. Technical Publishing Co., Ltd. 387 pp. 5s. net.

THIS useful little manual, of which another volume will be published, is designed to meet the existing need for a comprehensive work that will give the student all available information concerning the foundry and its products. Part I. deals with foundry equipment, materials used, and processes followed, describing the furnace itself, the cupola and its charge, cranes, hoists, etc., and the various methods of moulding and casting. Machine moulding and kindred subjects, however, have been left to be dealt with in the second part, which will also include chapters upon physical testing, shrinkage and distortion of castings, the various methods of cleaning castings, foundry costs, etc. In an introduction to the work the author points out that the foundry can hardly be said to have kept pace with the rapid advances made of late years in most departments of the iron and steel industry. But the near future will see the culmination of the present growing tendency towards specialisation, when every shop and every workman will be confined strictly to a particular class of work, and there will be no foundries for general work. "Moulding machines will be employed in greater numbers and variety, adapted to the work; the purchase of pig-iron by analysis will become universal, and foundries will be better equipped with suitable appliances for transporting the cupola charges and the molten metal, a system of narrow-gauge tracks extending throughout the entire works."

It is suggested that there is much room for improvement in regard to the methods of casting, and in this connection the author advises the use of the camera to record the successive stages during the progress of any unusually difficult piece of work, so that in the event of its having to be repeated at some later date, the method previously employed may be inspected and followed, or possibly improved upon. The various processes and plants are efficiently illustrated by over 200 views and diagrams, and a methodical index adds to the value of the book.

"THE AUTOMOBILE: ITS CONSTRUCTION AND MANAGEMENT."

Cassell and Co., Ltd. 608 pp. 10s. 6d. net.

THIS handsome work is taken from the French of M. Gérard Lavergne's "Manuel Théoretique et Pratique de l'Automobile," but it is something more than a mere translation, Mr. P. N. Hasluck, the editor, in an endeavour to give the public a thoroughly up-to-date treatise, having re-written the original book throughout in a more condensed style, and introduced a large amount of entirely new matter, descriptive of mechanisms that have made their appearance during the last year or so. In an exceedingly interesting and practical manner, Mr. Hasluck has thus succeeded in presenting all that is known concerning motor vehicles of every kind. The book will show the engineer how the mechanism with which he is familiar is applied in motor construction, how the technical difficulties arising from this novel application may be overcome, and what yet remains to be done in this rapidly-growing industry. After a brief historical sketch and detailed consideration of the various motive agents, a description is given of the methods of determining the requisite horse-power and its transmission to driving wheels. Axles and steering gear, wheels and tyres, springs, under-frames and bodies, brakes and lubrication are dealt with in separate sections; and this analysis having been made, the elements are grouped according to the chief types of existing cars. Then the notable results, officially or otherwise confirmed, are recorded, and finally attention is directed to the lines on which progress in the direction of increased efficiency is to be sought. In this connection we learn that in the petrol car improvements will be secured by the better employment of the carburetted mixture, thus eliminating to a large extent the unpleasant smell; by the obviation of the necessity for using cooling water, and by rendering starting easier. The efficiency of transmission needs to be increased, and should be made the subject of comparative experiments. Not more than 6 or 7 per cent. of the energy of petrol spirit is actually burned to account; but even this rate of efficiency is greater than that of the steam car, which is (adopting 1·5 kilogrammes as the consumption per effective horse-power-hour) only about 5 per cent. "Certainly," we read, "cars now regarded as the most improved will, in the course of twenty years, be looked upon as being barbarous." In conclusion we read:—

> What remains to be accomplished in the construction of automobile should not prevent a recognition of the importance of what already has been done in the short period of time since the renaissance of motorism. The automobile is a practical road vehicle, whose compulsory stoppages on the road tend to become exceptions due to disorder in the ignition system, a hitch in the working of the pump, punctured tyre, etc., all these being so many cases of stoppage which can easily and even rapidly be set right. The mistrust of the public, caused by the inprudence of some individuals, soon must be dispelled, and then automobilism will be safe and economic and enter completely into the customs of the day.

The book should prove of exceptional value and absorbing interest to all who own automobiles or who are engaged in the motor industry. The many examples of motors and their component parts are efficiently illustrated by 506 line engravings, and the printing and general get-up leave little to be desired.

NEW CATALOGUES AND TRADE PUBLICATIONS

These catalogues may be had free of charge on application to the firms issuing them. Please mention PAGE'S MAGAZINE when you write. Manufacturers of Engineering and Electrical Specialities, etc., etc., are invited to forward for review in this column copies of their catalogues, price lists, and circulars, as soon as issued.

The Richards London Machine Tool Company, Laurence Pountney Hill, London, and Paris.—Section A, 1902. A booklet of 56 pages and cover with an illustrated index and price list of their general catalogue of machine tools. The first portion treats exclusively of the new 1901 Patent Open-side Planing Machines, which they claim to be the most noteworthy development in modern machine tools. The machines are made to plane from 28 in. to 30 ft. long, and from 12 in. to 48 in. wide, and by the use of the "extension arms" to 60 in. wide. Some eight or ten drawings illustrating practical examples of the application of the machine are specially interesting, and we must express our appreciation of the excellent half-tone blocks with which the catalogue is profusely illustrated. At the end of the book is given a list of telegraphic words, which will be useful to foreign buyers.

The British Thomson-Houston Company, Ltd., Rugby.—Pamphlets Nos. 130, 131, 132. The first deals with their Type CE Continuous Current Stationary Motors, which are built for slow speeds, in sizes ranging from 2 to 15 h.p., and for moderate speeds in sizes from 3 to 20 h.p. The motor is symmetrical in form, and may be quickly arranged to run in an upright, inverted, or semi-inverted position. It may therefore be installed on the floor, ceiling, or wall. Pamphlet 131 deals with the Reavell Patented Duplex Type of Motor-driven Air Compressors, which are fitted with relief valve, drain-cock, and outlet connection screwed 1 in. gas. The motor runs at about 1,200 revolutions per minute, and drives a compressor at about 400 revolutions per minute, through gear wheels. The machine is designed for delivery pressures up to 30 lbs. per square inch, and only occupies a space of about 30 in. by 30 in. by 16 in. Pamphlet 132 describes the GE 58 Traction Motor. This motor is so designed and constructed as to be suitable for both narrow and standard gauges, with a minimum width of 3 ft. 3⅜ in., and is intended, for comparatively heavy service. Accompanying the pamphlets is a leaflet, with prices of their Direct Current Type CE Shunt Wound Motors.

Standard Engineering Company, of Leicester and Kettering.—An illustrated pamphlet of eight pages, describing their blowing and exhausting fans, including drawings and a table showing the various dimensions in inches. Their principal specialities appear to be right-hand and left-hand blowing and exhausting fans, both bottom, horizontal, and up discharges. The table above mentioned, though the figures are only approximate, is a very useful adjunct.

The Combination Metallic Packing Company, Ltd., of Gateshead-on-Tyne.—A well-designed catalogue of twelve pages and cover, printed in four colours, dealing with the principal speciality of this firm—viz., metallic packings. We are told that the packing is designed to suit either horizontal or vertical engines, is suitable for all speeds, self-adjusting as to wear, and, "once fitted, is no trouble to those in charge of the engine." A list of well-known names in the engineering world is given as an indication of the popularity of these packings, and, we understand, 80,000 sets, or an aggregate of 3,000,000 h.p., have already been fitted. The sectional drawings showing the different modes of application are exceptionally interesting.

Toope's Asbestos Covering Company, Ltd., Stepney Square, London, E.—A catalogue and price list, of twenty-four pages and cover, dealing with the "Toope Patent Pure Asbestos," the "Toope Patent Hair-felt Coverings," their "Asbestos Infusorial Silicate Plastic Composition," and a silicate papier-maché non-conducting composition, for covering or coating steam boilers, steam pipes, hot-air or blast pipes, cylinders, superheaters, and vacuum pans ; also for protecting water-pipes, tanks, etc., from frost. For the asbestos many advantages are claimed, the principal of which is that it acts as a perfect non-conducting medium between the steam pipes and the atmosphere, and prevents the radiation of heat and condensation of steam in its transit from boiler to cylinder. Another interesting speciality is their non-conducting removable coverings, which are made in sections, 3 ft. long, to fit on pipes any diameter, from ½ in. to 2 ft., and from ¾ in. to 6 in. in thickness.

The Hughes-Johnson Stamping, Ltd., Langley, Birmingham.—This is a neat little booklet, entitled "Drop-forgings," describing and illustrating their various specialities in steel manufactures, viz., weldless eye-bolts of many designs, bow nuts, weldless wrought steel swivels, machine spanners, lathe carriers, shaft collars, lathe chuck jaws, level and handle ends, hooks of various kinds, and a variety of automobile forgings. Particular attention is called to their roller boiler tube expander, which, it is claimed, can be used where it would be difficult or impossible to use the ordinary tool; and an additional advantage is that one of the tube expanders can be adapted to tubes of several sizes.

The Library Supply Company, 181, Queen Victoria Street, E.C.—We have been favoured with some advance sheets of a new catalogue which this firm will shortly issue, and if the collection before us may be taken as a fair criterion, the completed catalogue will reflect much credit on its designers. The principal speciality of this firm is the manufacture and supply of up-to-date office furniture, special attention being given to the fitting and furnishing of town halls and public buildings, libraries, museums, technical schools, insurance offices, banks and business offices generally. Another speciality worthy of notice is the card-system, and a particularly interesting illustration shows a double-desk cabinet for cost records. This, in addition to 24 ordinary drawers, has 104 slide trays, and affords capacity for 190,000 cards. The card-system is very highly spoken of as a simple labour-saving device, and applied to the indexing of correspondence, drawings, special tools, etc., is proving itself an indispensable adjunct to the office equipment of the engineer.

Andrew Handyside and Co., Ltd., Britannia Ironworks, Derby.—Catalogue C.—This is an illustrated book of designs for fountains and vases cast in iron and bronze, and costing from £1 to £1,200. The Britannia Ironworks, Derby, is, we are told, one of the oldest foundries for this purpose in England. The cover design is one of exceptional merit. A striking combination of light and shade is heightened by the novel colour scheme. The artist shows a model fountain, the amber waters of which are sharply outlined against a background of black and olive green, introducing a terrace and parterres. The trees beyond are silhouetted in black, and the artist has cleverly rendered the sparkle of the water from the fountain. White is employed only for the words "Fountains and Vases—Handyside," which are thus made to stand out incisively without detracting from the design. There are also some particularly fine inset plates, drawn to scale, illustrating to great advantage some of their magnificent ornamental cast iron and bronze work in fountain vases, and the drawings both of these and fountain-head and basin designs, as well as the ornamental garden vases, of which there are some thirty examples, are particularly interesting. Altogether a very useful catalogue, and one from which much useful information as to the cost and mode of fixing fountains can be obtained.

Babcock and Wilcox, Limited.—A second edition of their interesting work on "Patent Water-Tube Marine Boilers" has just come to hand. The subject matter embraces articles such as The Water-Tube Boiler: Its Status; Requirements of the Marine Water-Tube Boiler; Description of the Babcock and Wilcox Boiler; Comparison with Shell Boilers; Re-boilering U.S. Monitors; Notes on Corrosion: Causes and Preventative Measures; Points of Interest in connection with Vessels fitted with Babcock and Wilcox boilers, etc., and includes a large quantity of most valuable data obtained from trials of Babcock and Wilcox boilers on shore and at sea. The record of Babcock and Wilcox boilers in American war vessels during the late war with Spain appears to be of exceptional merit, and forms a striking commentary on the statement so frequently made in the Press that water-tube boilers are unreliable and exceedingly costly in repair. A perusal of the article on corrosion and the accompanying tables should be helpful to every sea-going engineer. The subject is very clearly treated, and a description given of an apparatus supplied to all ships in which Babcock and Wilcox boilers are installed for determining chemically the amount of chlorine, if any, in boiler water. The book is profusely illustrated, and many of the plates are of a high order. It is well printed on art paper, and is bound in green cloth. The pages have ample margins and are clearly arranged, and the volume, apart from its technical value, is a valuable addition to the library.

Howard Bros., Liverpool.—An illustrated catalogue and price list of twenty pages and cover, describing in "pithy" style the use of the "Dey" Time Register, which we understand has lately been considerably improved by various additions and alterations. This Time Register is made in different sizes for accommodating fifty to two hundred employees. It prints the exact minute in a very convenient form on a paper sheet inside the machine, which cannot be tampered with. Each record is separate and complete in itself, and no matter in what order the employees come in or go out, their numbers are bound to appear in consecutive order on the time slip, with all the registrations for day or week (as the case may be) printed in bold type, giving the exact hour and minute at which they register, in one line opposite each man's number. A concise time sheet is thus furnished, showing a complete record at a glance. Several highly commendatory letters from customers of many years' standing are reproduced. That the machine is very simply constructed is demonstrated by a half-tone illustration of its interior. It is consequently blessed with almost complete immunity from the vexatious and oftentimes costly irregularities to which complex mechanism, in all forms, is so liable.

No. 5. Vol. I. ONE SHILLING NET. November, 1902.

PAGE'S MAGAZINE

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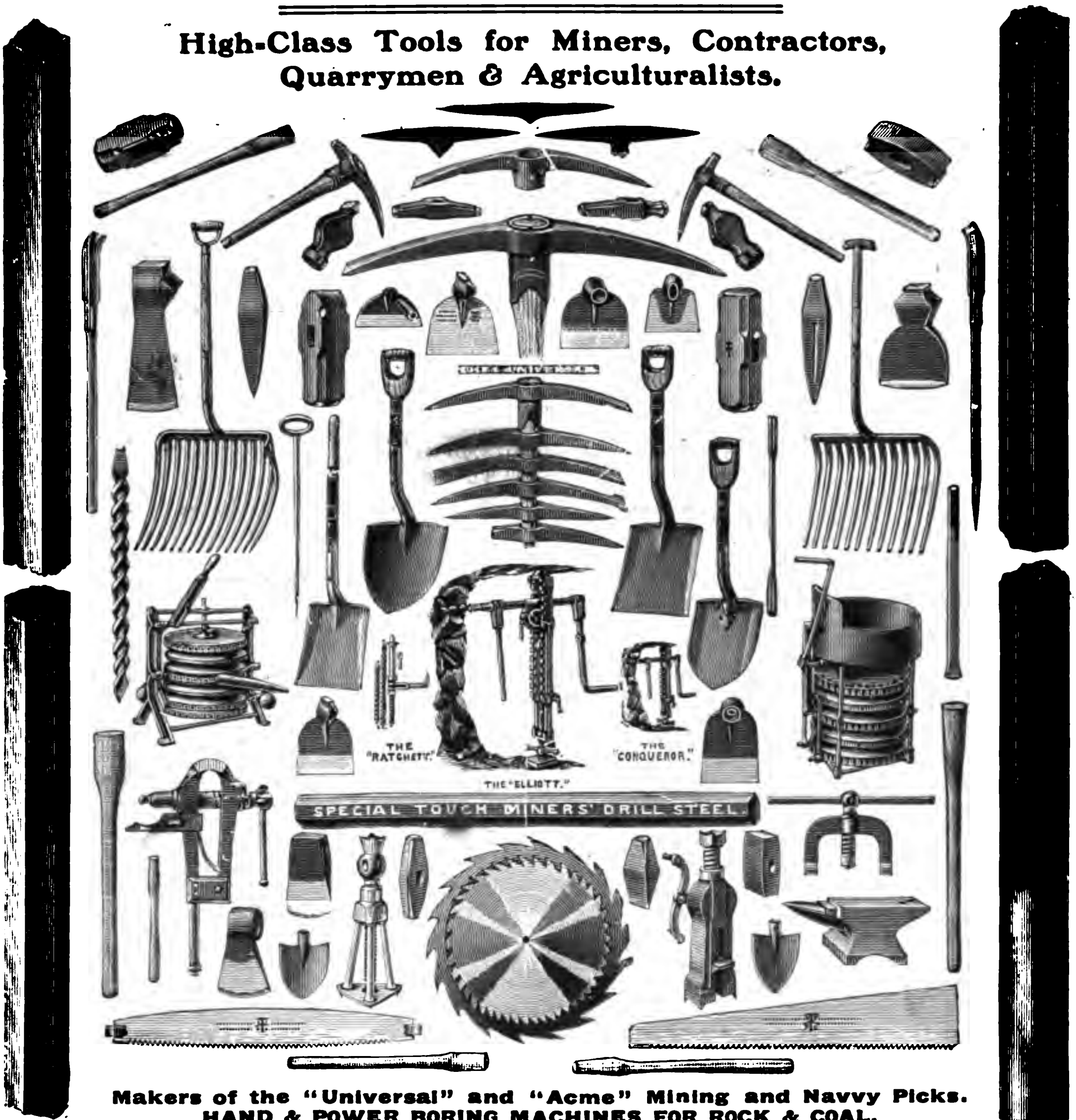
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CONTENTS

No. 5. NOVEMBER, 1902. Vol. I.

BOILER SHOP (WATER-TUBE BOILERS), GERMANIA SHIPBUILDING YARD, KIEL . . . . . Frontispiece

MILLING MACHINES—V. . . . **Joseph Horner** . . . 491
Treats of Vertical Spindle Milling Machines. With Fifteen Illustrations.

THE GERMANIA SHIPBUILDING YARD, KIEL **John Leyland** . . . 506

WORKSHOP PRACTICE 518
A Résumé of Machine Tools, Cranes, and Foundry Matters for the Month. With Illustrations.

THE DEVELOPMENT OF "WIRELESS" TELEGRAPHY—III. **C. H. Marillier** . . . 523
Deals with a number of inventors whose work has not yet attained the range of prominence of Signor Marconi's. With Twelve Illustrations.

NOTES AND NEWS 534

NAVAL NOTES . . . . . **N. I. D.** . . . 538
Monthly Notes on Naval Progress in Construction and Armament. With Five Illustrations.

IRON AND STEEL MANUFACTURE
Fourth Article **B. H. Thwaite, C.E.** . . 546
Charging of Mineral and Furnace Equipment.

ARE BRITISH RAILWAYS INSOLVENT? **Charles Rous Marten** . 562
Deals from an entirely independent standpoint with the interesting controversy opened in the *Times*.

BUSINESS SYSTEM AND ORGANISATION—III. **D. N. Dunlop** . . . 568
The Cost of Production. Illustrated.

THE CRITICAL POSITION OF PIG IRON **Benjamin Taylor** . . . 575

COMBINATION AND COMPETITION **Charles Lancaster** . . 579

LOCOMOTIVE ENGINEERING NOTES 584

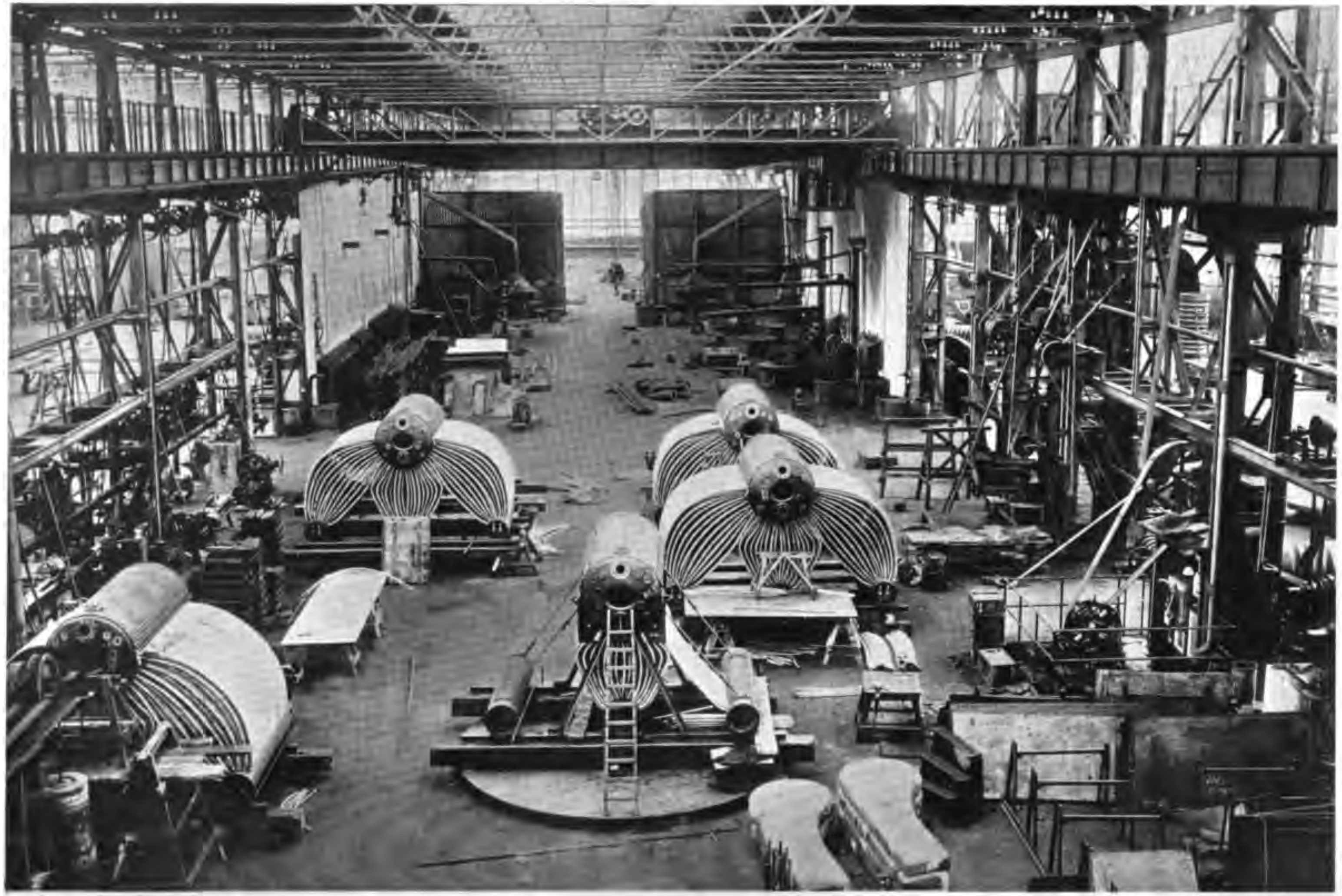
OUR MONTHLY RÉSUMÉ . . **The Editor** . . . 587

NOTABLE BRITISH PAPERS OF THE MONTH 594

REVIEW OF LEADING CONTINENTAL PAPERS 599

BOOKS OF THE MONTH 606

NEW CATALOGUES AND TRADE PUBLICATIONS 608



BOILER SHOP (WATER-TUBE BOILERS), GERMANIA SHIPYARD, KIEL.
See Article by John Leyland.

PAGE'S MAGAZINE

An Illustrated Technical Monthly, dealing with the Engineering, Electrical, Shipbuilding, Iron and Steel, Mining and Allied Industries.

VOL. I. LONDON, NOVEMBER, 1902. No. 5.

MILLING MACHINES.

BY

JOSEPH HORNER.

Treats of Vertical Spindle Milling Machines.

*Fifth Article.**

THE advantages which the vertical spindle machine possesses are so obvious in certain classes of work, that there is practically no choice between these and the horizontal. Face mills are used much better and more frequently on these than on the horizontal types, in which edge mills predominate, and although, when the face of the work is vertical, there is the advantage that the cuttings fall away readily, which they cannot do from a horizontal face, this advantage is but slight compared with the other benefits which follow from the horizontal position of the work. Of course, the chips can be brushed off frequently, and a hand brush is generally kept for the purpose. Sometimes also a suction pipe is arranged over the table, with an exhaust fan connected to draw away the cuttings, though this plan is not very common as yet.

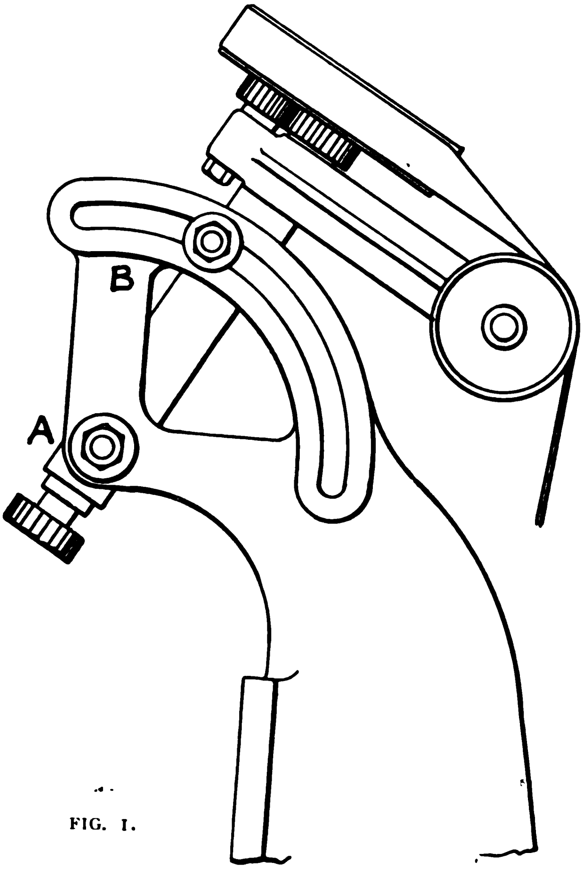


FIG. 1.

The chief advantages of having the face of the work horizontal are that it is well under observation, that it is the best position when heavy masses have to be handled, and that

---

* The previous articles dealt with the various classes of Lincoln type machines (July); the general design of the pillar and knee types (August); the universal indexing and dividing heads, tailstocks, and other fittings (September); and boxes of gears for producing positive feeds—also circular milling and vertical spindles (October). The series is illustrated throughout.

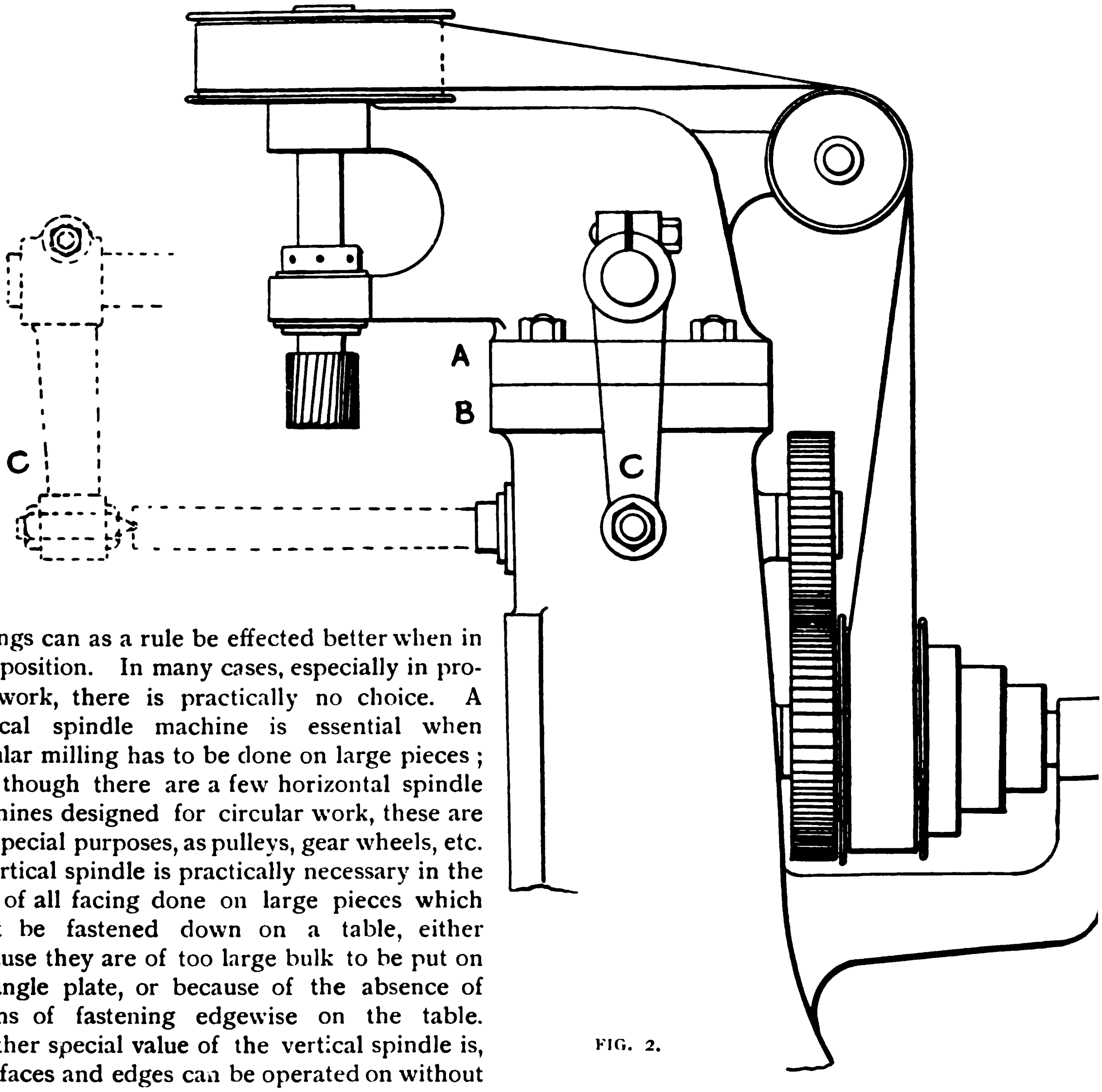


FIG. 2.

settings can as a rule be effected better when in that position. In many cases, especially in profile work, there is practically no choice. A vertical spindle machine is essential when circular milling has to be done on large pieces; and though there are a few horizontal spindle machines designed for circular work, these are for special purposes, as pulleys, gear wheels, etc. A vertical spindle is practically necessary in the case of all facing done on large pieces which must be fastened down on a table, either because they are of too large bulk to be put on an angle plate, or because of the absence of means of fastening edgewise on the table. Another special value of the vertical spindle is, that faces and edges can be operated on without re-setting the work; face mills on the first, and edge mills on the second. We therefore find that large vertical machines are more frequently used than large horizontals, except the rotary planers, which are a class by themselves. But taking the Lincoln millers, and the pillar and knee machines, we have very few examples of these which can compare with the heaviest vertical spindle machines in size.

THE GENERAL TYPE.

Probably the largest number of heavy and medium vertical millers made are built on what we may term the drilling machine, or slotting machine model. A broad base, an upright of box section and an overhanging head cast in one piece, carry the milling spindle and driving gears on the head, and the upright receives the sliding knee with compound tables for traversing or rotating the work under the cutter. This type occurs in many variations, and is a popular and useful machine. It follows that of the slotting machine in another particular. In very heavy tools the knee model is abandoned, and the main frame is extended in front from the upright, to form a bed resting solidly on the ground, and carrying the compound slides. The advantage of this design is that larger pieces of work will clear the upright, and that a larger

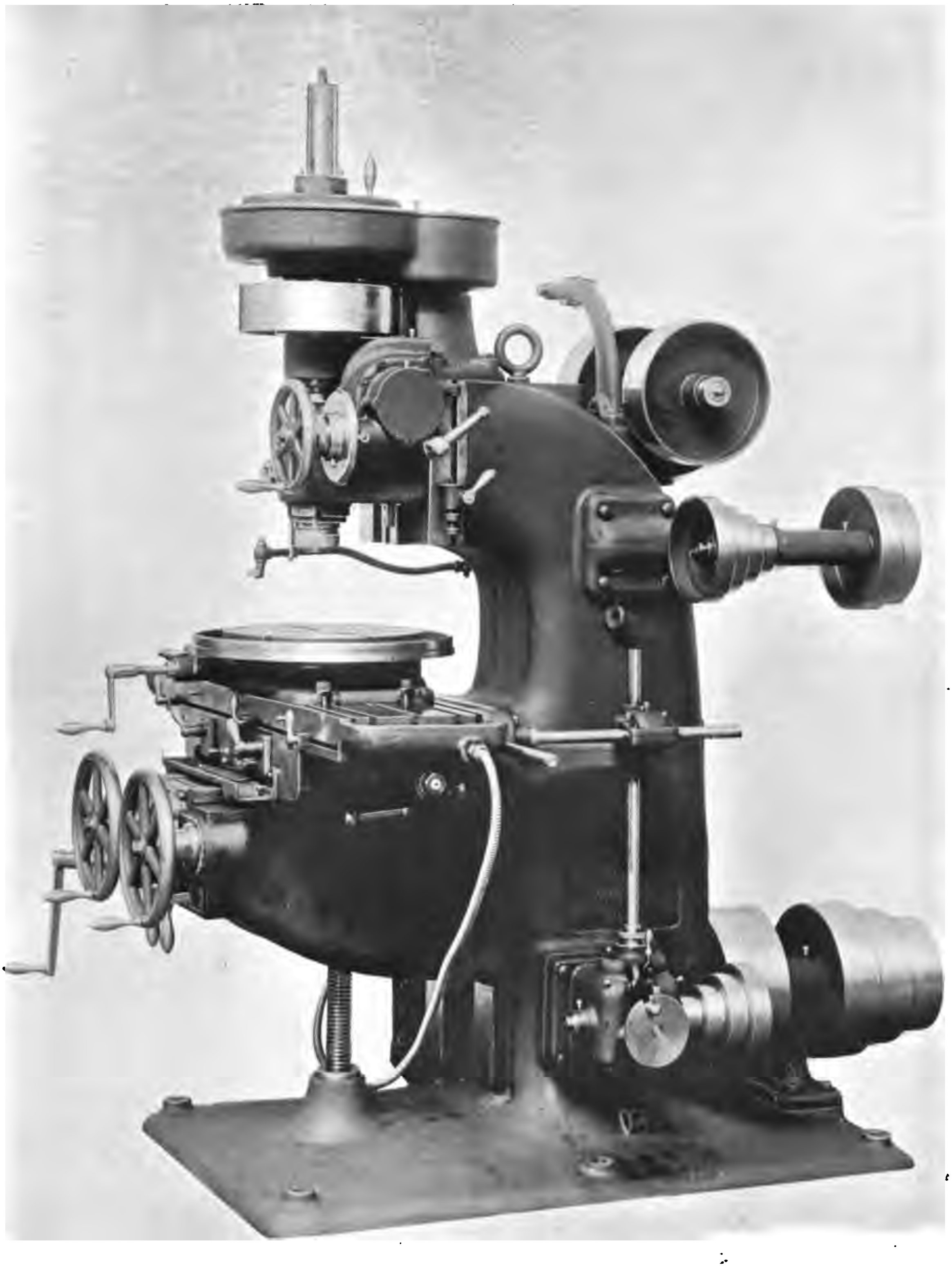


FIG. 9. TWO AND FIVE-EIGHTH-INCH SPINDLE MILLING MACHINE. BY A. HERBERT, LTD., COVENTRY.

traverse in the direction of the upright is obtainable.

Illustrative of the conservatism of practice observable in many of the vertical machines of the slotting or drilling type, is the retention of geared drives. In some the resemblance is exact, the stepped belt cones —back-geared—driving a pair of bevel wheels, one of which is keyed on to the cutter spindle. Modern ideas are not favourable to the retention of the geared drive, a simple high-speed belt drive on to the spindle being preferred, and fitted now by many manufacturers.

In the vertical machine the weakest points have been the knee, the upper portion of the framing, and the spindle fittings. The knee, therefore, is abandoned in many machines, not only of large size, but in those of moderate dimensions, and the base rests on the foundation. The upper portion of the framing is made of very massive proportions by firms who understand the necessity of avoiding all possible clatter and vibration. The spindle is of large diameter, and of a good quality of steel, and provision is made for supporting the arbor below the cutter—the same provision which exists in the horizontal spindle machines. The best machines of to-day, therefore, bear little resemblance to those of a few years since.

THE SPINDLE HEAD AND SLIDE.

It is necessary to make the spindle head of a milling machine movable in order to afford support close to the cutter at all heights of its range. This, it may be observed, is a device which is adopted in many modern drilling machines, and one which is absent from many of the older types, thus causing unsteadiness when drilling down deeply.

In the vertical machines, the slides which carry the spindle and milling cutter are counterbalanced, and provision is made for vertical adjustment to suit varying heights of work, either by hand or power, much in the same fashion as drilling heads are operated. If adjusted by hand, a hand wheel at the side of the machine

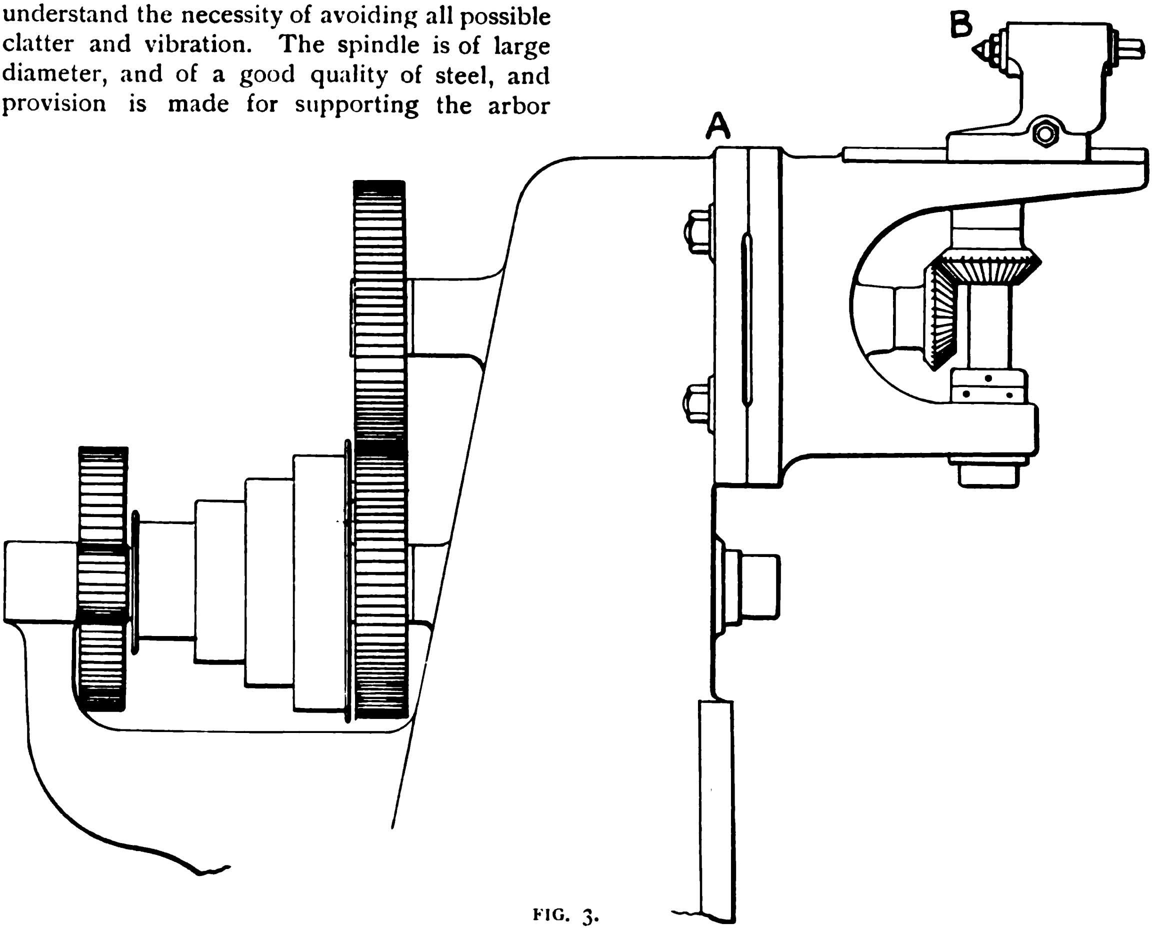


FIG. 3.

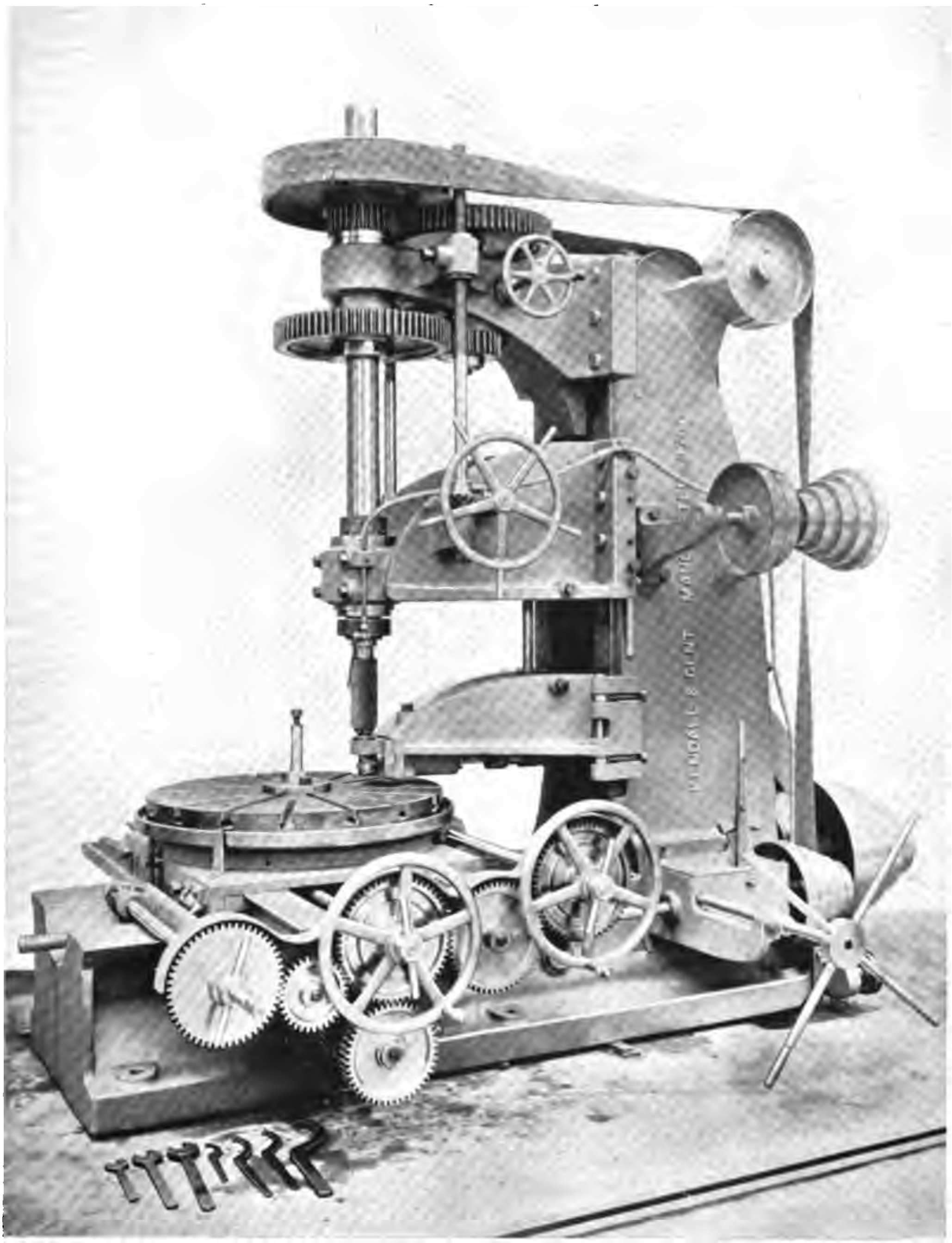


FIG. 10. FIVE-INCH SPINDLE MILLING AND PROFILING MACHINE. BY KENDALL AND GENT, MANCHESTER.

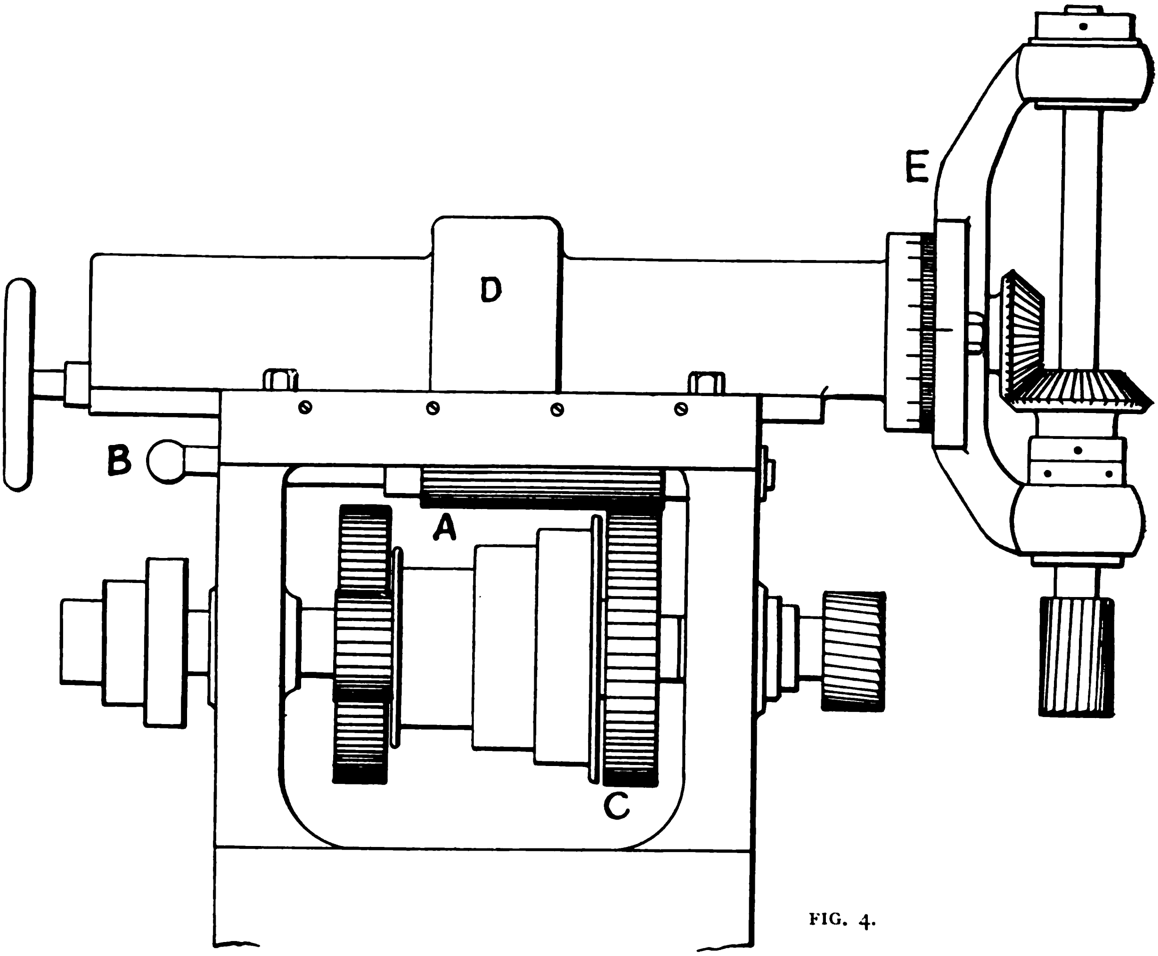


FIG. 4.

within easy reach of the attendant actuates spur gears above, by which the vertical feed screw is turned. If by power, the feed is through worm gear, operated by a belt pulley. In some of the lightest machines a treadle is used to pull the head down. This is of especial value in die sinking, as well as in other departments of work.

COUNTERBALANCING.

The weight of the spindle head is differently balanced in various machines. In some a weight is carried overhead, sustained by cords that pass over small guide pulleys, carried at the top of pillars. In a few, a horizontal lever has a weight at its extremity. In a neater pattern, a weight concealed within the framing is suspended by a cord or cords, or in some cases by chains passing from the head over guide pulleys. The lightest spindles are counterbalanced by a coiled spring above.

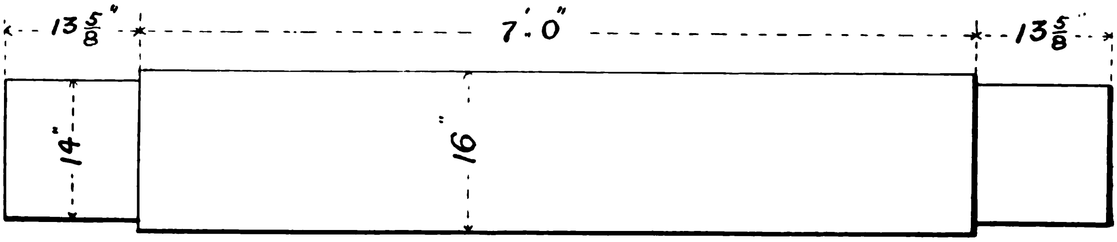


FIG. 4.

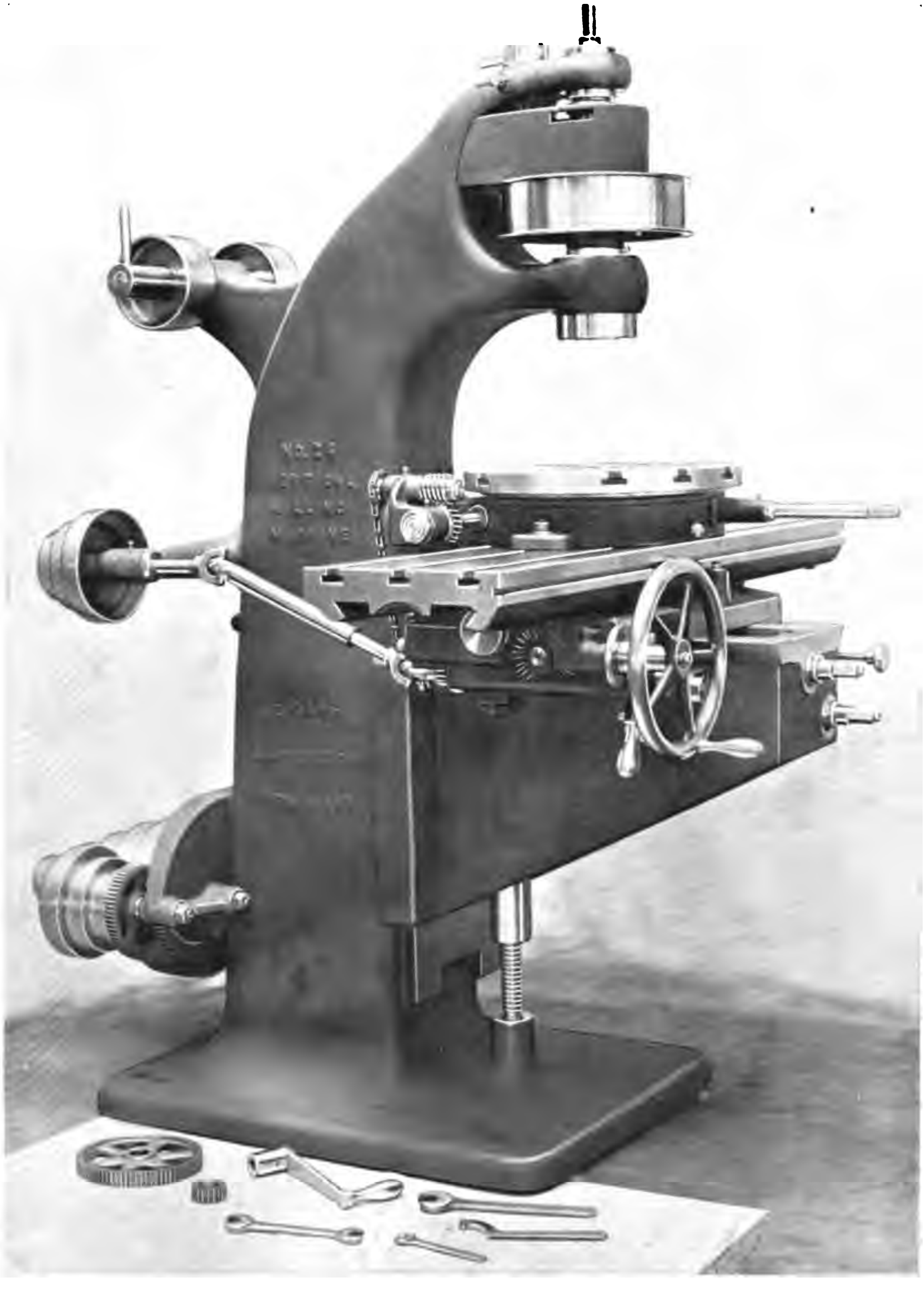


FIG. II. VERTICAL MILLING MACHINE. BY THE GARVIN MACHINE COMPANY.

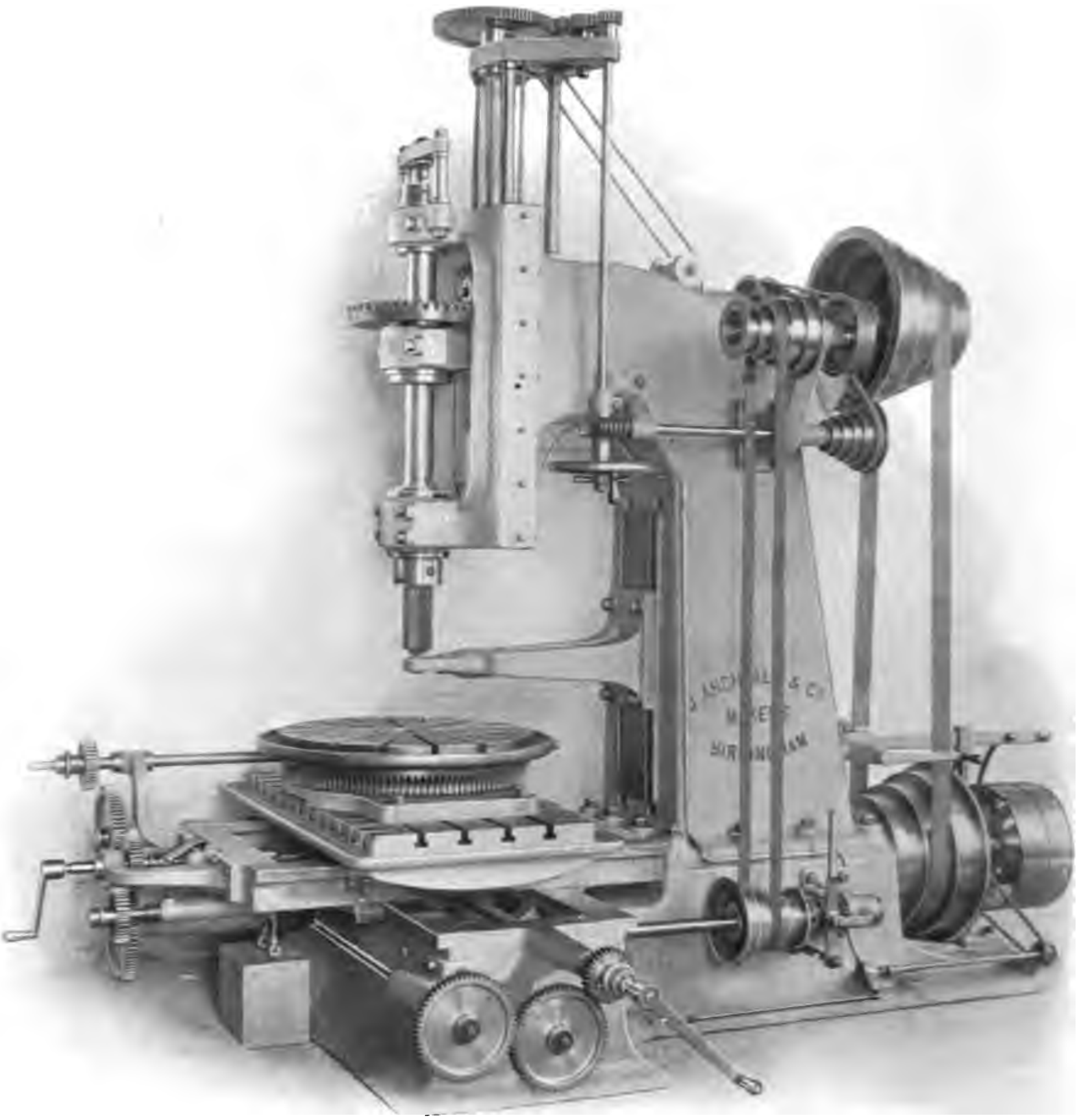


FIG. 13. THREE AND A HALF-INCH SPINDLE VERTICAL MILLING MACHINE.
BY JAMES ARCHDALE AND CO., BIRMINGHAM.

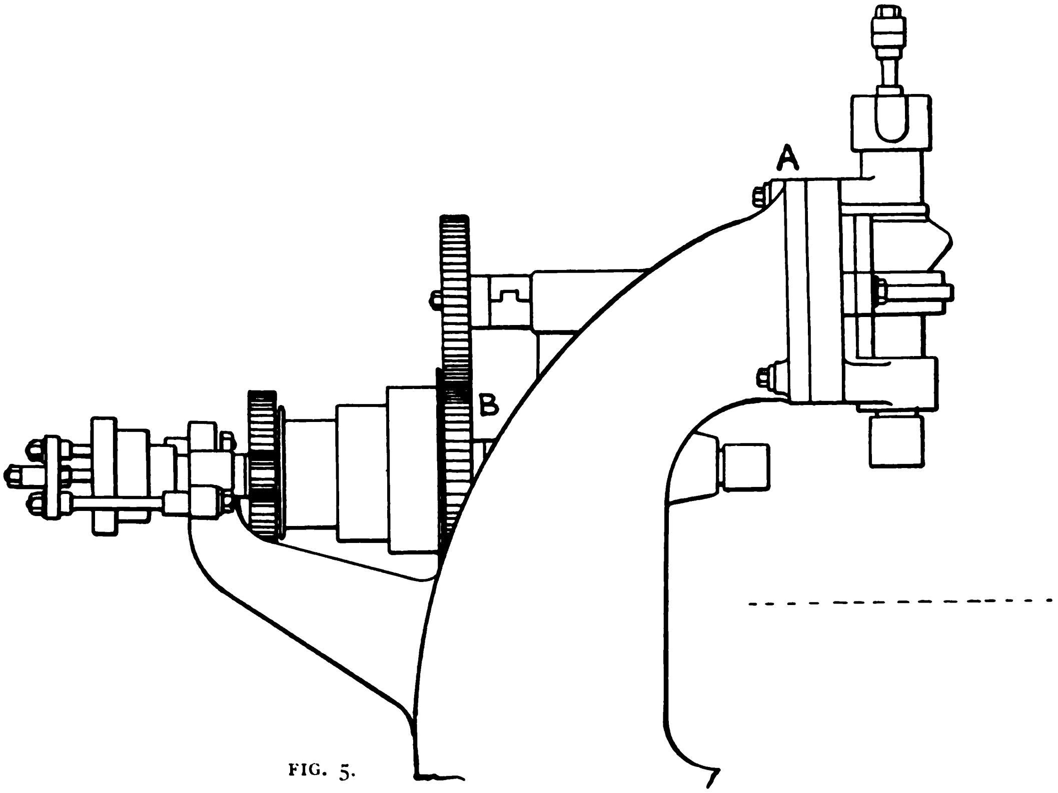


FIG. 5.

TRANSITIONAL OR COMBINED FORMS.

Reference was made in our last article to the combination of vertical and horizontal spindles, of which an illustration was given. So much is done in this way, that we may consider these machines as affording transitional links between the two great types.

CONTINENTAL MILLING HEADS.

The milling machines by the firm of Pretot, of Paris, have the spindle bearing pivotted near the cutter end, A (fig. 1), and moved about a quadrant-shaped head at the other, B, in which it can be clamped at any angle, from horizontal to vertical. In the small machines, the spindle bearing is adjusted by hand, as in fig. 1. In the larger sizes, a hand wheel actuating mitre wheels turns a screw in a nut, which is connected to the bearing through the quadrant slot. The screw is pivotted to give freedom of movement at varying angles. The driving and guide pulleys are carried in a cast frame of U-shape, which is attached to the upper end of the bearing. The small spur gears seen within the belt pulley are used in conjunction with two others, hidden by the pulley, to give a slow geared drive—back gears in fact—and used in cases where a more powerful cut is required than the belt drive alone can stand up to.

A curious Continental design by Vautier and Co. contains provision for vertical and horizontal milling by two separate spindles (fig. 2), the vertical one having to be swivelled to one side to permit of the horizontal one being used.

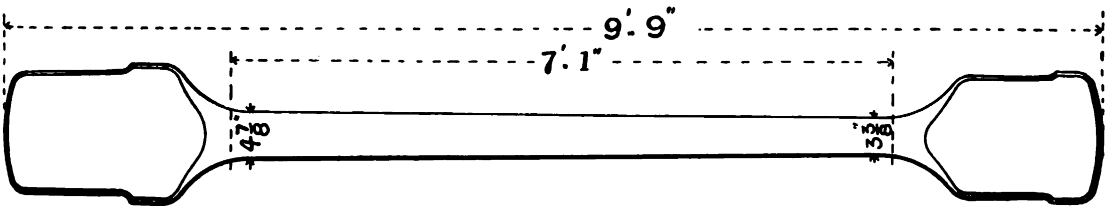


FIG. 5.

The vertical head, A, therefore swivels on the top of the pillar, B, to any horizontal angle, and this is taken advantage of to perform angular milling without swivelling the table as in the common design. To use the horizontal spindle, when the vertical head is swivelled around 90 degs., an overhanging centre, C, carried in the head comes into place to support the cutter arbor, as indicated in dotted outline. There is no back gear, but the spindles are belt driven only, the vertical one with a belt coming from the cone pulley over guide pulleys, the horizontal one from the cone pulley through one pair of equal spur gears.

A French device is illustrated in fig. 3, by Bariquand and Marre, in which the machine is shown arranged for vertical milling. The vertical spindle is driven from the horizontal one, through spur and bevel gears. When the horizontal is in use the head is turned round 180 degs. on the vertical face, A, so bringing the overhanging centre, B, into position in line with the horizontal spindle. The head can be also set to any vertical angle on the face, A, of the upright.

In a head by Sculfort and Fockedey the two spindles are arranged as in fig. 4. The driving of the horizontal spindle is done from the stepped pulleys, either directly or through back gears. That of the vertical one is derived from the horizontal, without back gear. It is effected by the long sliding pinion, A, which, to obtain this result, is pushed by the knob, B, into engagement with the wheel, C, on the cones. It is in constant engagement with a pinion enclosed in the hood, D, which encloses a horizontal shaft, and so drives the vertical one through equal bevels. The bracket, E, which carries the vertical spindle and gears, pivots on the face of the top casting, and can be set to any vertical angle.

The diagrams (figs. 5 and 6) illustrate an Italian head by Edmondo Dubosc, of Turin. This also swivels on a vertical face, A, on the column. Here also two spindles are used, the vertical one being thrown round 90 deg. when the horizontal is in service. The driving of the horizontal spindle is through a spur wheel, B, from the back gear wheel next the large step of the cone. The swivelling head carries a

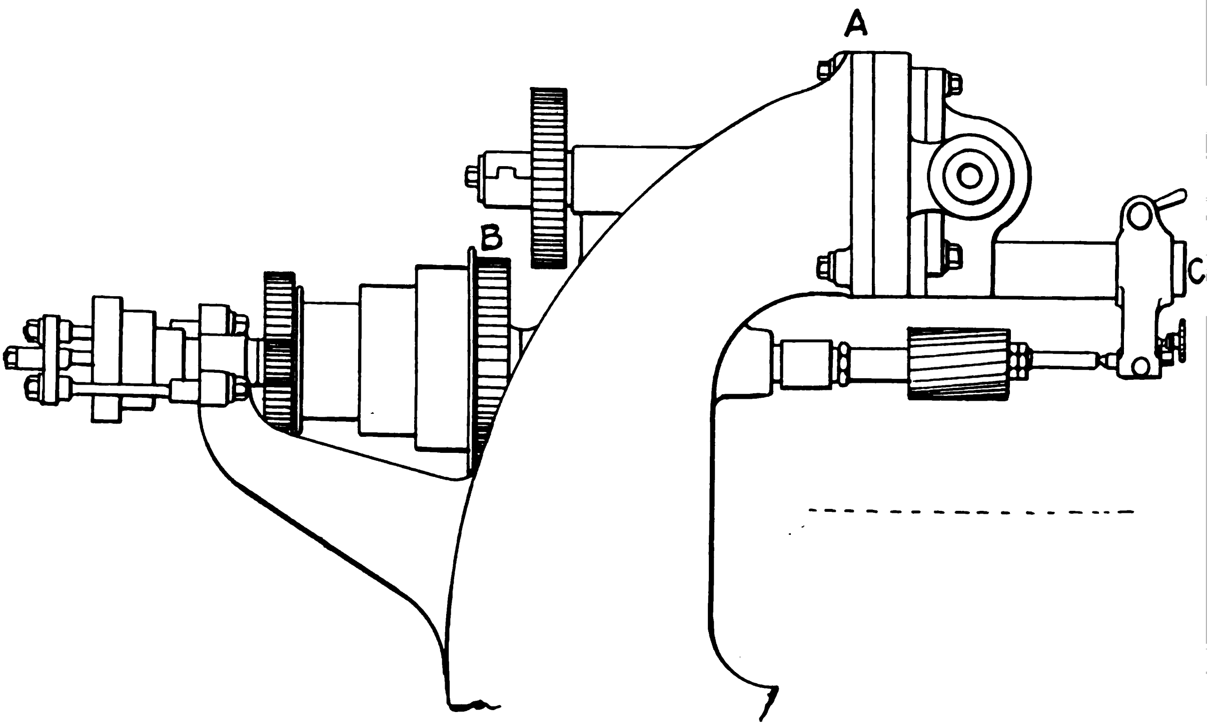


FIG. 6.

socket to receive a steady bar, C (fig. 6), and centre to support the overhanging end of the arbor for horizontal milling.

THE REINECKER MACHINE.

A vertical machine (fig. 7), by J. E. Reinecker, represented in England by Pfeil and Co., has a swivel head with a large and substantial circular base attached to a face on the main frame. The single spindle is driven through stepped cones and bevel gearing, and is back-geared, driving through bevels, the gear arrangements being identical in any position of the spindle from vertical to horizontal.

THE VAN NORMAN MACHINE.

The Waltham Watch Tool Company make a very unique machine with a head that swivels from vertical to horizontal. The head fits on one side of the main frame, and the latter has a movement of 9 in. in and out over the top of the column, the movement being operated by a hand wheel. The overhead arm, compound tables, and knee are similar to those in other machines. But the machine is rope driven, the rope being made of woven strands of raw hide lacings. The rope starts from a groove on the main pulley, which is at the rear of the machine on the main driving shaft, and belted from the countershaft. It passes from the pulley over a series of idler pulleys which change its direction of motion to the cutter spindle. Tightening pulleys are fitted near the bottom, being mounted on a movable block which slides on two upright rods, and is adjusted with a ratchet lever, and pawl-locking device. Although rope driven, this is not a very light machine, for it weighs about a ton. The spindle is back-geared. The table is 36 in. long, and has an automatic feed of 22 in., and the knee has a vertical range of 18 in.

The foregoing designs, of which there are various modifications, have not become popular in England. Apart from exceptionally good design and workmanship, the combination form is not considered favourable to stability and accuracy. There is no question of the handiness of the arrangement, especially in the smaller shops. But apart from these, and other exceptional cases where angular and vertical and horizontal milling are combined in the same pieces, it is better to have horizontal and vertical machines distinct.

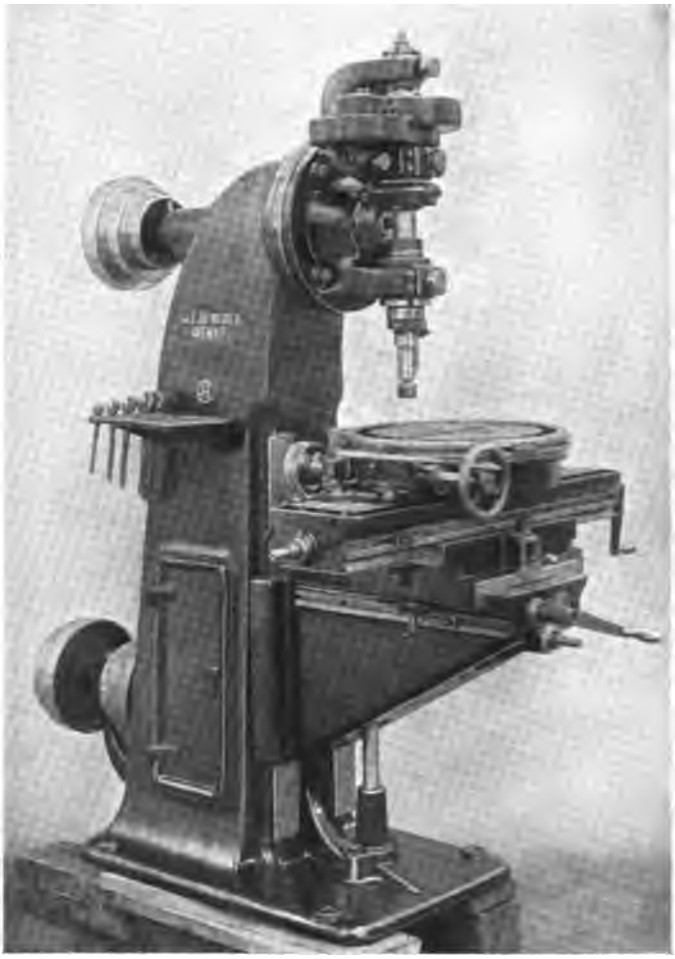


FIG. 7. VERTICAL MILLING MACHINE, WITH SWIVEL HEAD. BY J. E. REINECKER, CHEMNITZ-GABLENZ.

We will now resume our account of strictly vertical machines, and give a selection of illustrations of this type.

THE BECKER-BRAINARD MACHINES.

These machines, for which Messrs. Selig, Sonnenthal and Co. are the English agents, are of an excellent design, and have been the model upon which others have been largely built.

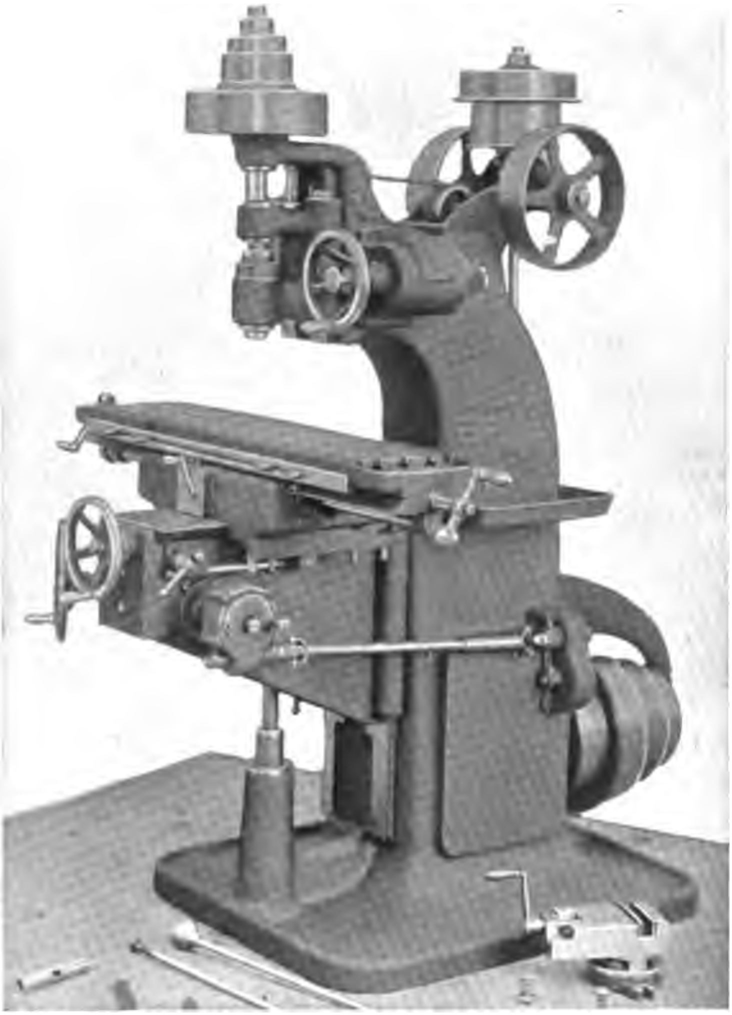


FIG. 8. VERTICAL MILLING MACHINE. BY THE BROWN AND SHARPE MANUFACTURING COMPANY.

They are all belt driven, and all have knees adjustable on their columns. The main frame is stiffly built, and is a single casting arching over to the spindle bearings.

In the nine or ten sizes in which they are built, the spindles range from 1 in. to 4¼ in. in diameter, the weights of the machines ranging from 11½ cwts. to over 3 tons. A feature by which they are all characterised is the fitting of an auxiliary support to the upper end of the spindle, which is mounted on the head of the main frame casting, and adjustable thereon. It takes the pull of the belt immediately under the belt pulley, and so relieves the spindle there of the belt strain and friction, and preserves its alignment. As it becomes worn it can be readjusted by slackening the bolts, and moving it forward with a set screw.

The smallest sizes of these machines are run at high speeds, and the vertical movement of the spindle is controlled by a foot lever. The head, being counterbalanced, returns automatically when the pressure of the foot is removed. Both hands are thus left free to manipulate the table slides. A stop gauge, with micrometer readings, regulates the depth of cut. In the larger sizes of machines the foot lever is abandoned, and, in the largest of all, a hand wheel, with worm gears, is provided, and the tables, operated by hand in the smaller sizes, have their movements made self-acting, including that of the circular table. The spindle ends are threaded to receive large face mills. A feature in these machines is the gripping jaws, which work in combination with the tee slots of the table in place of a vice, with the advantage that any width up to the limits of the table can be gripped, whereas with a vice the length of work held is limited by the capacity of the vice opening.

THE BROWN AND SHARPE MACHINE.

Figure 8 illustrates the latest vertical spindle machine by the Brown and Sharpe Manufacturing Company. A circular table, though not shown in the illustration, can be fitted when required. The machine is belt driven, and is not back-geared. The spindle has twelve changes of speed, utilising two speeds at the counter. They range from 85 to 1,260 revolutions per minute. The lower end is bored to a No. 10 B. and S. taper. The arbors are held by a bolt that passes through the spindle. The head has a vertical movement of 4 in. by hand wheel, provided with means for either rapid or fine adjustment. A micrometer stop controls the depth of cut. The table feeds are automatic in each direction, with automatic release, and they can also be reversed by a lever in front of the machine. There are twelve changes of feed, with index, ranging from ·005 in. to ·125 in. per revolution of the spindle.

THE HERBERT MACHINE.

The latest vertical machine, by Alfred Herbert, Ltd., of Coventry, is shown in fig. 9. It is belt driven, with cut back gears, which, like the rest of the wheels, are enclosed. Several sizes of this type are made, the one illustrated having a 2⅝-in. spindle. The knee moves on long sliding faces, and the weight of the overhanging portion is carried on a stout vertical adjusting screw. A point to observe is that all the operating hand wheels and handles are brought to the front of the machine, from which the attendant need not move away.

The spindle slide is counterbalanced. It is raised and lowered by the hand wheel in front, which actuates a worm and wheel, and a rack and pinion. A micrometer adjustment is fitted by means of a graduated dial behind the wheel. The vertical movement of the head is regulated for any number of pieces by an adjustable dead stop seen in front. Just above it is a handle by which the slide is locked to the face of the frame during cutting. The distance from the spindle centre to the column is 16 inches.

The spindle bearing is of hard phosphor bronze, adjustable to take up wear. The nose of the spindle is threaded to receive large cutters. It is bored with a No. 10. B. and S. taper hole, and is provided with a positive clutch drive for ordinary arbors. The arbors are attached with a draw bolt passing through the spindle. A good point is that the belt pulley runs on a sleeve instead of directly on the spindle, so that the latter is relieved from the pull of the belt. The spindle has twelve changes of speed, including that provided by the back gear and a two-speed counter, varying from 13·5 to 333 per minute. The vertical movement of the spindle is 7½ in., that of the table 12 in., and the maximum distance from the surface of the table to the spindle is 19 in. The compound table slides have a longitudinal feed of 36 in., and one in the transverse direction of 12 in., automatic in either direction with stops. A circular table is fitted, detachable, with automatic feeds in each direction, and it is indexed around the edge. The maximum distance

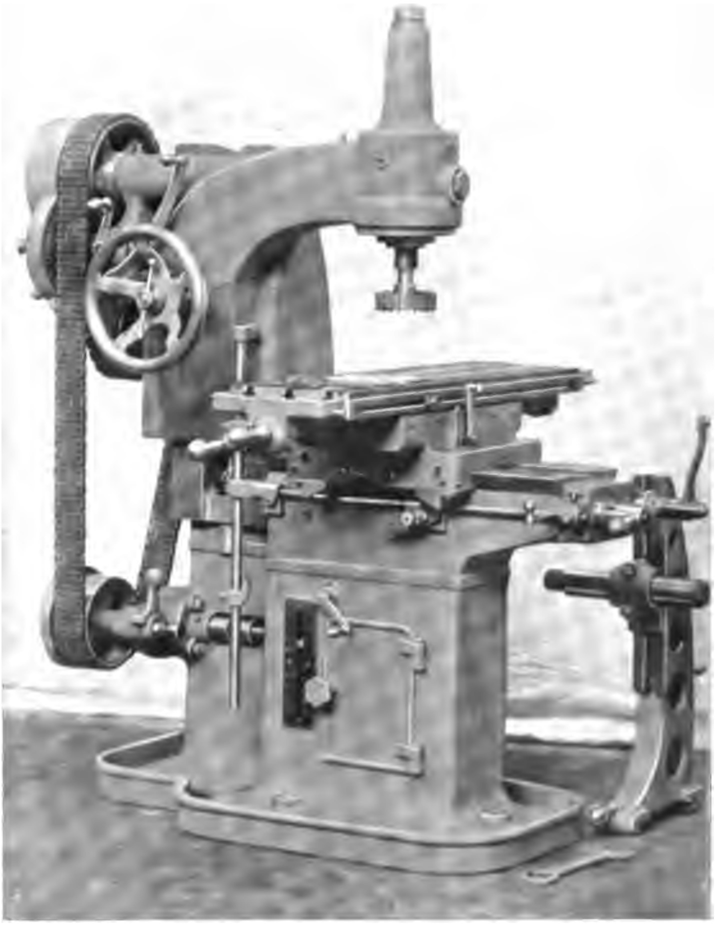


FIG. 12. VERTICAL MILLING MACHINE. BY THE RICHARDS MACHINE TOOL COMPANY, LONDON.

from the top of the circular table to the spindle nose is 14 in. The adjustments are all properly indexed.

The spindle feeds are through the small four-stepped cones, driving gears in a box at the base of the upright. Sixteen changes are thus provided, varying from ·334 in. up to 8·5 in. per minute. An oil pump, tank, and fittings are provided for the cutters, and the circular table has an oil channel around its edge.

THE KENDALL AND GENT MACHINE.

A very fine specimen of a vertical milling and profiling machine, by Kendall and Gent, of Manchester, is shown in fig. 10. It is the largest but one of a series of five manufactured by this firm, in which the spindles range from 2 in. to 6 in. in diameter. It has a 5-in. spindle, and weighs 13 tons.

In these machines the upright and long base are cast in one. The upright carries three brackets. One is bolted fast at the head to receive the spindle and back gears; another, a sliding bracket, supports the lower end of the spindle from minimum to maximum heights—in this case ranging from 10 in. to 2 ft. 6 in.; and the third is a hinged bracket, which steadies the lower end of the arbor when using face mills, and carries the profiling roller. The base receives the compound tables, and a circular table; with automatic feeds, and reversing motions to each.

The machine, though of such large dimensions, is belt-driven, with the result that no bevel wheels are employed. Only the back gear spur wheels are retained, being necessary for heavy cutting, and these are not on the driving cones, but in direct connection with the main spindle, in accordance with what is now considered the best practice. There is no good reason why this should not be so. These features are also embodied in many of the later drilling machines, and ordinary lathes have always had their back gears next the cone pulleys; indeed, there is no reason why other machines should have the gears separated widely from the cones with no apparent advantage.

The movable bracket which steadies the lower end of the spindle is raised and lowered by the hand wheel seen in front of it, actuating two screws, driven by two pairs of angle wheels. The nuts of the screws are carried on the fixed bracket above. The lower bracket or steady is hinged, so that it can be turned aside when face cutters are being used. It also contains provision for vertical adjustment.

The table gears, which are all protected, contain provision for the movement of the slides by hand, and automatically; the double-ended levers seen in front of the hand wheels locking or loosening them. Graduated rules and pointers are fitted to these, and also to the vertical slide on the upright. The circular table is divided round and fitted with a pointer. It has an oil tray around it, and a mandrel is fitted in the centre.

The speeds are obtained from the four-stepped cones at the rear, below, doubled by the back gears. When the back gears are thrown out, high speed cutting for finishing cuts and work on brass and gun-metal can be done. The feeds are derived from a four-stepped pulley carried on brackets on the upright, driving to a similar pulley set in a reverse position below. A worm at the end of the lower shaft actuates a worm wheel through which motion is communicated to the spur gears which actuate the slides. An index plate is attached to the machine, giving the rates of feed on the various steps. A centrifugal pump, seen at the base of the machine to the right, supplies lubricant to the cutters.

THE GARVIN MACHINE.

A belt-driven Garvin machine, for which Messrs. Burton, Griffiths and Co. are agents, is illustrated in fig. 11. Some of the best points of this machine are not in evidence in the photo. They are the following: The feed of the table is by a screw rack cut on the underside of the table. The worm by which it is driven runs in oil, is of bronze, and is divided to take up slackness. The feed gears run in oil, and are well protected. The circular table, which is fed by hand, has its worm and wheel encased. The worm can be thrown out of engagement in order to bring the table round to any point at once. The table can also be locked in any position. Its edge is graduated into degrees. The table elevating screw has a ball thrust, and the screw does not pass through the floor. In other respects the machine possesses features common to high-class tools of this kind—such as a stiff knee of boxed section, a large hand wheel, automatic feeds, and trips to the table slides, the arbor secured, and removed by a screw, and micrometric adjustments to the slides. There are sixteen changes of speed by cone, back gear, and counter, and twelve changes of feed.

THE SCULFORT AND FOCKEDEY MACHINE.

In a heavy vertical machine by the French firm of Sculfort and Fockedey, of Maubeuge, a rather novel method of guidance and stiffening of the spindle is adopted. The sliding head only embraces the lower portion of the spindle, the upper part sliding in a fixed capped boss at the top of the machine. The spindle is stiffened by two circular guide bars, one on each side, fixed in the movable head below, and in a cross head above the top of the machine. The weight is counterbalanced. The idea apparently is simplicity in fitting, though at the same time a splendid stiffening effect is imparted to the sliding head with the cutter, enabling it to withstand very heavy duty without tremor.

THE RICHARDS MACHINE.

A stiff vertical spindle machine (fig. 12) is made by the Richards Machine Tool Company; it is link-belt driven, and generally embodies the details of the horizontal machine, as described in the first article of this series. Its attachments include a horizontal spindle and rack-cutting device. The arm and spindle have a vertical feed of 16 in. on the column of the machine, with automatic stops. The arm is moved from the end of the machine by the crank handle, with readings of $\frac{1}{1000}$ in. For rapid adjustments, the hand wheel at the side of the arm is employed. There is a wide range of feeds from $\frac{1}{800}$ in. to $\frac{1}{4}$ in. per revolution of the spindle, and these can be changed or reversed by the small crank at the front of the frame, while the machine is running. The spindle has sixteen speeds, including those obtained by back gear.

THE ARCHDALE MACHINE.

Fig. 13 shows a fine machine by James Archdale and Co., of Birmingham. It weighs 6½ tons, and admits 2 ft. 4½ in. in height above the circular table, which measures 2 ft. 6 in. across. The rectangular table is 4 ft. 3 in. long by 2 ft. 2 in. wide. The spindle is 3½ in. diameter. It is fitted with a profiling attachment, and can also be used for boring and drilling.

The spindle is carried in a slide, which is provided with hand wheel, and with self-acting variable feed motion for boring, and the weight is counterbalanced by chains and a weight inside the hollow column. The variable down feed is through stepped cones, actuating a worm and wheel, thence to spur wheels above. The main drive is through stepped cones and bevel wheels to the spindle. The self-acting feeds to the tables, longitudinal, transverse, and circular, are variable through stepped cones belted from the driving spindle. The circular table is detachable. Troughs receive the waste lubricant, which is sent back to the cutter by a centrifugal pump fixed at the side of the column. The lower end of the cutter arbor is supported by a bracket which slides on the face of the column to suit the varying height of the spindle. The latter runs in hard gun-metal bearings, adjustable for wear, and end thrust is taken on an adjustable steel tail pin.

PROFILING.

Profiling is a special department of the work of the vertical milling machine, and one of its most valuable applications. In this branch any number of similar pieces of irregular forms can be produced from a pattern or former. The cutter is controlled by the former through the medium of a hardened steel pin, or roller, which is kept in contact with its edge, and coerces the movement of the cutter in a precisely similar manner. It is the same principle as that which is familiar in the Blanchard or copying lathe, for turning elliptical or other forms, but applied in a different manner. Some of the machines here illustrated are suitable for profiling, but this subject must be dealt with in another article, with illustrations of more highly specialised tools.

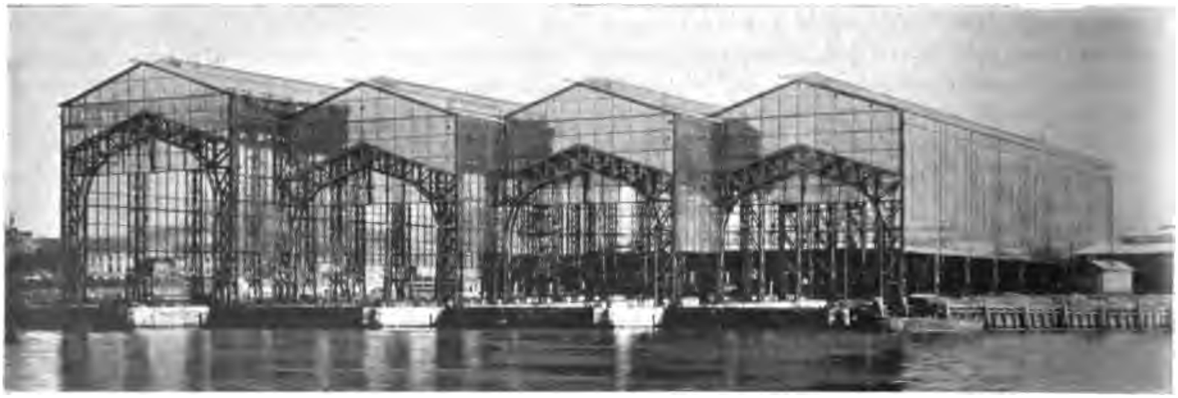
THE GERMANIA SHIPBUILDING YARD, KIEL.

BY

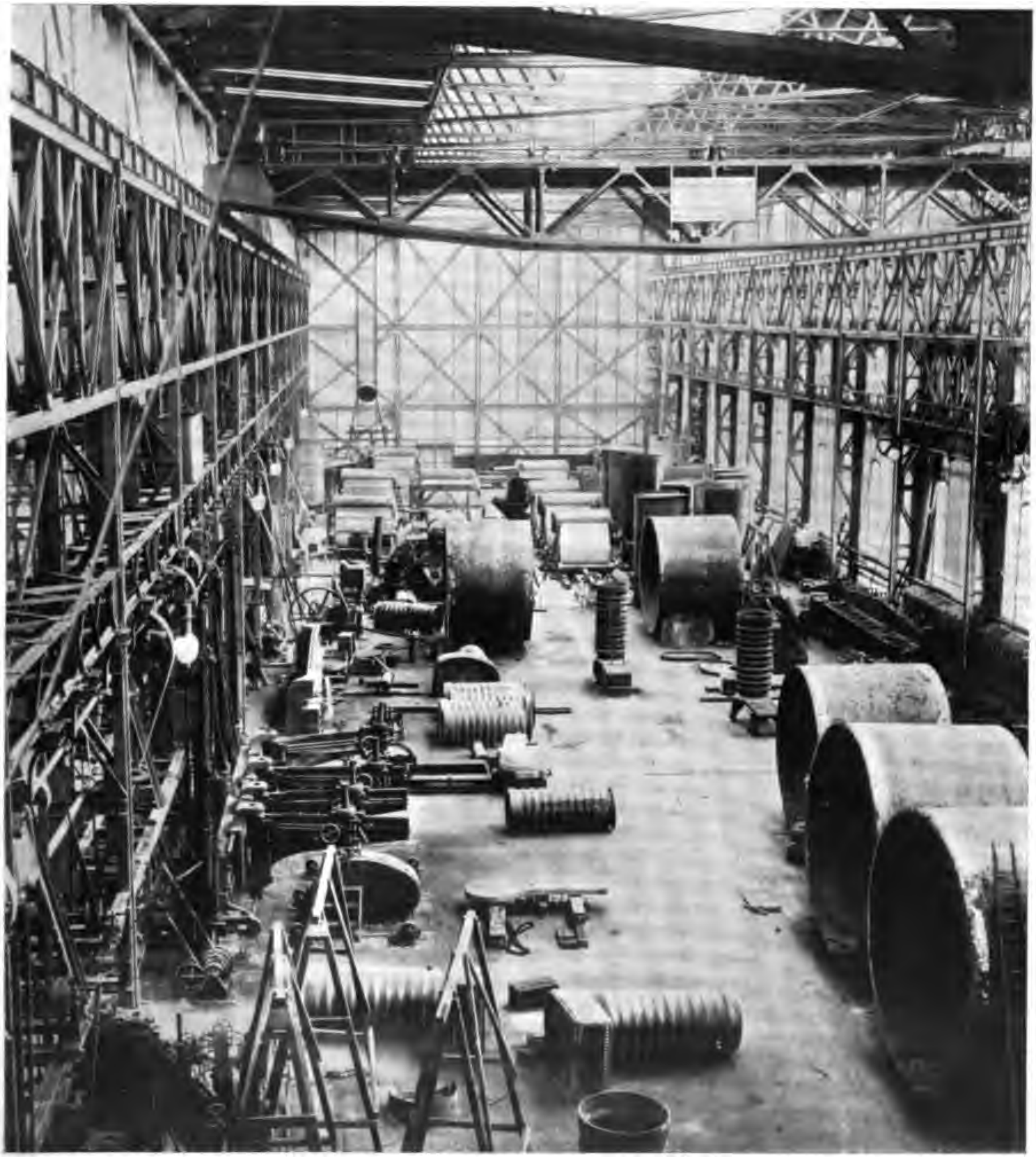
JOHN LEYLAND.

In this article Mr. Leyland sketches the rise and progress of the Germania Yard, shows its intimate association with German naval expansion, and describes some recent achievements.

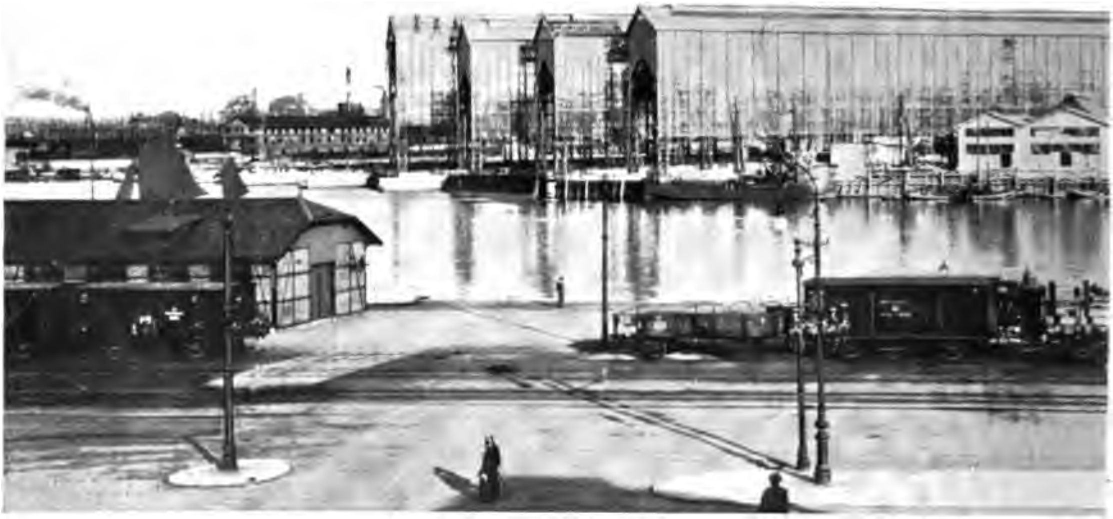
THE Germania Shipbuilding Yard at Kiel, which has been lately taken over by the great firm of Krupp, and is being largely developed by them, merits attention in this country, because of its rapid growth and the fact that it is bound up in its origin and purpose with the expansion of the German navy. The astonishing progress made by the Kaiser's fleet is undoubtedly one of the greatest factors in the politics of Europe, and within a measureable period the great force which is being created will play a large part in the affairs of the world. Those whose memories do not go back very far remember the time when the only navy outside our own that was worth serious consideration was that of France. The Germans knew nothing about sea-power. They were still engrossed in the building up of the State that had been created in 1871, were breaking down the barriers of Particularism, and were welding the empire more surely together. They were confronted with social difficulties, were enmeshed in the Kulturkampf, and were vexed with agrarian problems. The aspirations of the Great Elector and some of his successors towards naval expansion had been forgotten, and there existed in the inner mind of Germany a certain distaste for external enterprise. Bismarck had no sympathy with a colonial policy, but the world was wider than his horizon, and when at length Germany was aroused to the fact that the Fatherland could not live alone, the fairest parts



VIEW OF THE COVERED SLIPS.



BOILER SHOP (CYLINDRICAL BOILERS) AT THE GERMANIA YARD.



GENERAL VIEW OF THE YARD.

of the world for colonial enterprise were already in other hands, and German subjects were emigrating, to be absorbed in other nationalities. The Reichstag had constantly refused to vote money for naval purposes; but there were far-seeing Germans, and not any seeing further than the Emperor, who recognised that the welfare of the country and the growth of its commerce and industries, as well as its place among the nations, depended upon worldwide expansion—upon the creation of what the Emperor himself proclaimed as a "Weltreich." When, therefore, Germans looked around, and saw the countries capable of being colonised occupied by English settlers and traders, while their own unhealthy possessions were mostly the prey of functionaries, there was born in them that Anglophobe spirit which grew so bitterly during the war that the world wondered at the exaggeration of its tone.

GERMAN NAVAL EXPANSION.

Out of that spirit came the new Navy Law of 1900 which has done so much to promote the shipbuilding industries of the country. It was laid down that in order to protect German sea trade and colonies there existed only one means—she must have "a fleet of such strength that even for the mightiest Naval Power a war with her would involve such risks as to jeopardise its own supremacy." The outcome of that law, in 1920, when all the ships have been completed—built be it noted in German yards—even if no others be laid down—and there are obvious indications that a new programme, especially of cruiser construction, is contemplated—will be to give Germany 38 battleships, 20 large cruisers, and 45 other cruisers, with very large torpedo flotillas. I do not propose to go any further into the political or naval significance of these facts. The purpose is to show how great has been the stimulating influence of the new policy upon national industries, and particularly upon the development of shipbuilding resources, as exemplified chiefly in the surprising growth of the Germania Yard at Kiel. In 1870, Germany had seven iron and steel shipbuilding establishments, with a capital of 4,800,000 marks; in 1880, eighteen, with a capital of 15,300,000 marks; in 1890, twenty-five, with a capital of 36,100,000 marks; and in 1900, thirty-seven, with a capital of 66,000,000 marks. The full effect of the new naval and commercial policy was now felt, and,

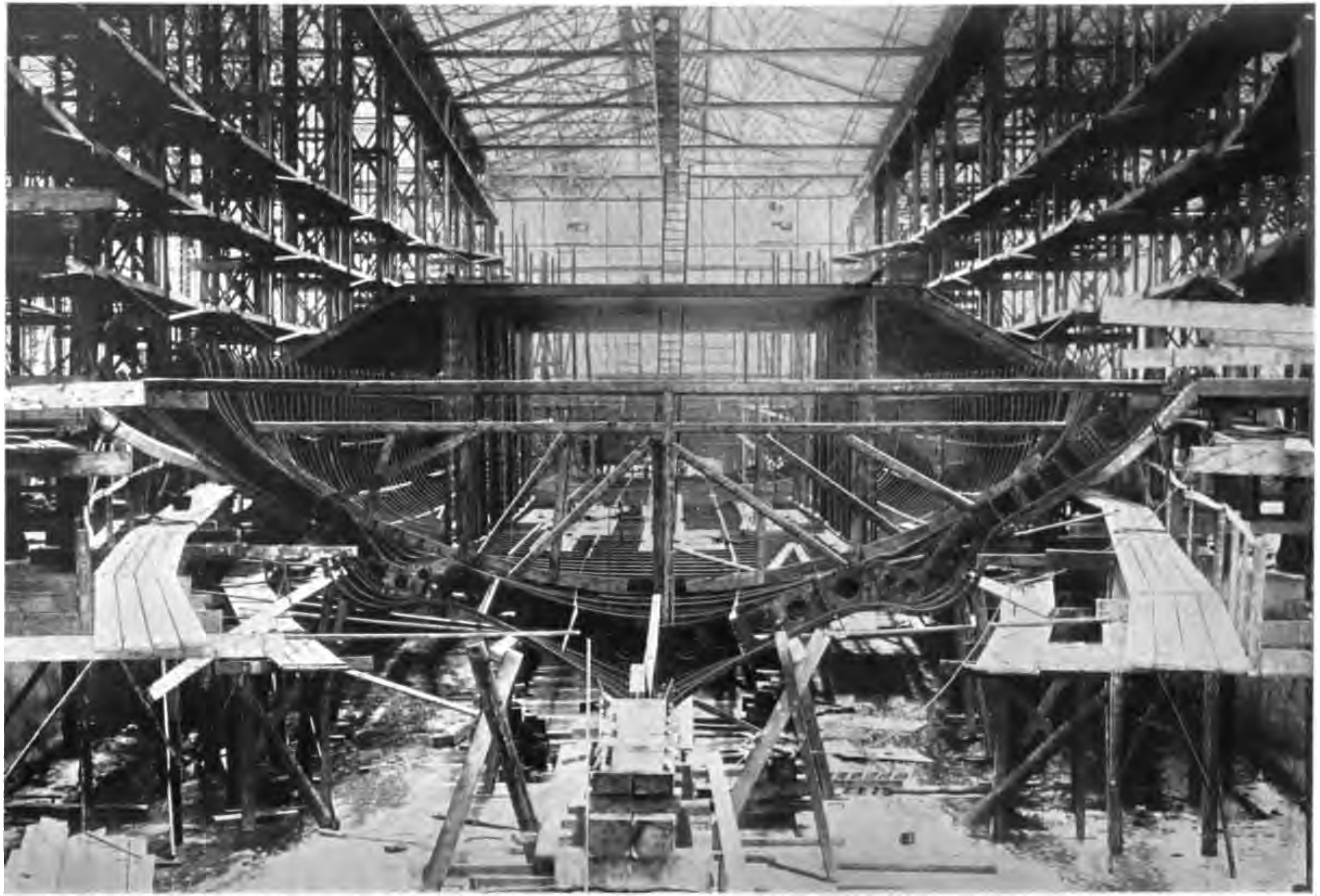
GENERAL VIEW OF THE YARD.

at the end of 1901, a sum of 66,000,000 marks had been embarked in some ninety establishments. It must ever be the case that where a definite, consistent, coherent, and enduring policy is adopted by a State, the manufactures and industries concerned will benefit immensely through the confidence that results. This seems to be a very important matter to all who are concerned in shipbuilding and the allied industries. They must look to the stimulating and vivifying effect of the enduring policy of their Government, to provide continuity of work, and to justify the investment of capital. Nothing can be more to the advantage of a State than the development of all those private establishments whose work conduces to its welfare. In Italy, policy has been weak and fitful; in France, incoherent; even in the United States uncertain; but in Germany, as in this country, there is a definite aim, and the Kaiser's Government is making giant steps towards its end. The 630,000 members of the German Navy League are its exponents, and the Colonial Party the solid base of its aspirations.

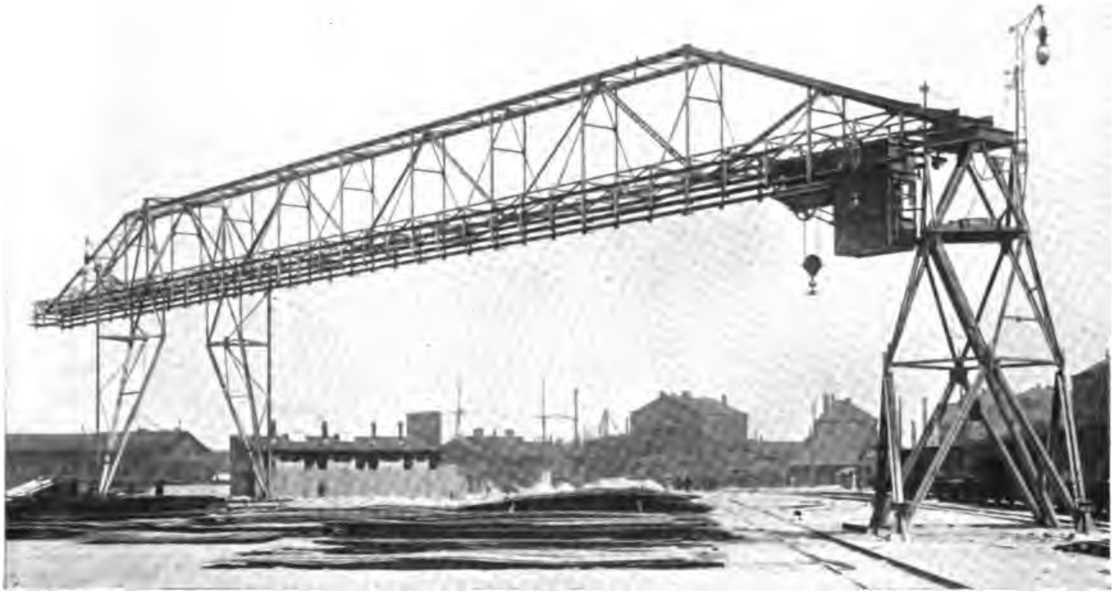
Without the new naval policy of Germany, the Germania Yard at Kiel could not have been what it is. It is now a part of the great establishment of Friedrich Krupp, and has an interesting history. In its origin, as a machine and engine works at Tegel, near Berlin, it was the first large establishment in Germany capable of building engines for warships, and it is now the only private yard in the country capable of building battleships complete in every particular of construction, protection, armament, and fittings. Its final completion is, of course, in its union with the great gun and armour plate works at Essen and Buckau, near Magdeburg, which, like the steel works at Annen, the blast furnaces in other parts of Germany, the three coal mines, the many iron ore mines in the country, and a share in those at Bilbao, in Spain, are all part of the Krupp establishment.

HISTORY OF THE GERMANIA YARD.

The history of the Germania Yard may be carried back to the year 1825, when F. A. Egell established in the Lindenstrasse in Berlin a machine shop, with ten workmen, which was presently enlarged and removed to the Chausseestrasse. Small stationary engines were built, and when the work increased, foundries and shops were built at Tegel, near Berlin. In 1871 the firm became a limited company,



INSIDE VIEW OF COVERED SLIP, WITH OVERHEAD TRAVELLING CRANES. BATTLESHIP "L" IN COURSE OF CONSTRUCTION.

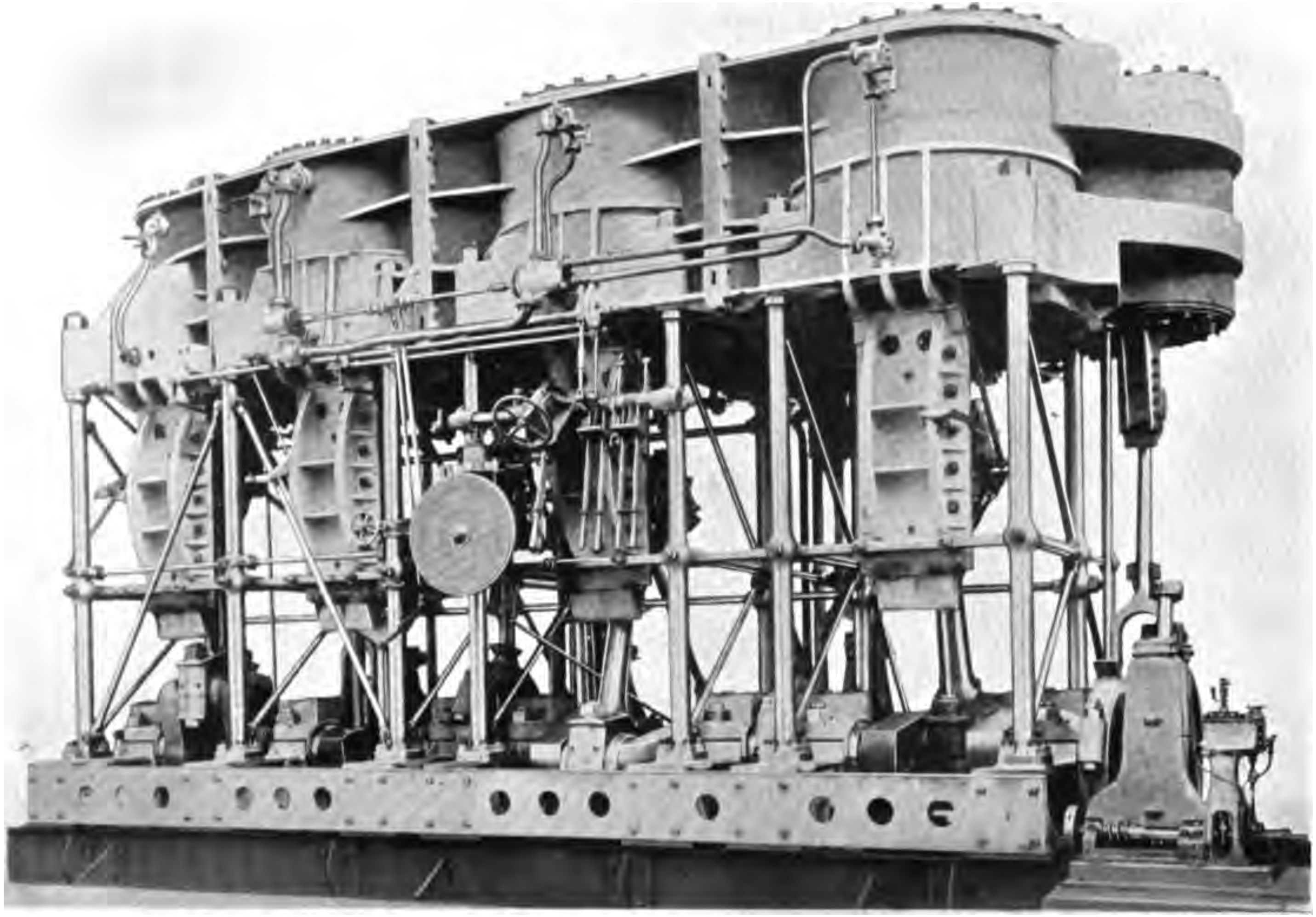


CANTILEVER CRANE FOR PLATEYARD.

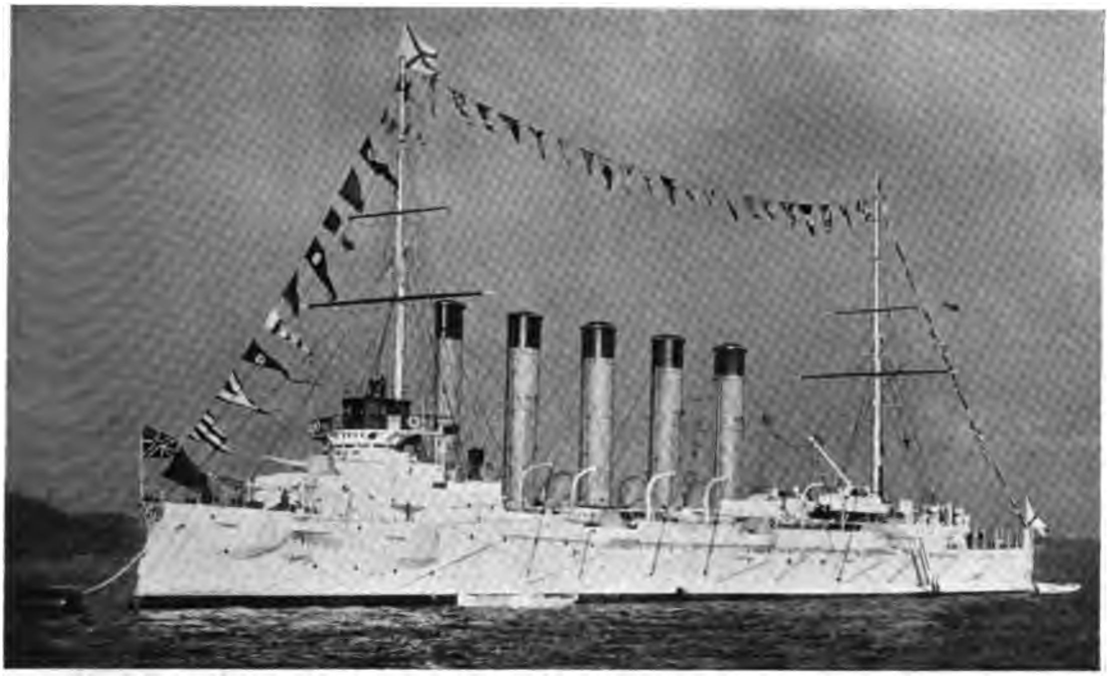
under the name of "Märkich-Schlesische Maschinenbau und Hütten-Aktiengesellschaft." A great part of the work of this company was in building ships' engines and boilers for naval and commercial purposes, and in 1879 the company bought the building establishment known as the Nord-Deutsche Werft at Gaarden, near Kiel, which had been founded in 1865. The operations were soon extended, and in 1882 the Germania Company was formed to carry on the work of the dual establishments at Gaarden and Tegel. A fresh development of this establishment took place in 1896, when the Krupp firm took over the management for a period of twenty-five years, with the right at any time before the expiration of the contract, to buy out the old company. This was brought about finally on April 1st, 1902, when the whole establishment was absorbed, and became known as the "Fried. Krupp Germaniawerft."

ITS CONNECTION WITH THE KRUPP WORKS.

It may be interesting to say, in this place, that the Krupp firm was established in 1810 by Peter Friedrich Krupp, who lived until 1826, having built smelting furnaces and other works. Alfred Krupp followed him, in whose time the Essen Works developed amazingly. He became the sole proprietor in 1848, and started the manufacture of weldless steel tyres. A 50-ton hammer was built, breech-closing mechanisms were introduced for big guns, the Bessemer process was started, rail and plate mills were established, and iron ore mines were opened. Then in 1867 came the proving ground at Essen, and in 1876 that at Meppen. The open-hearth Martin process was introduced, and the Annen Works were incorporated. Smokeless powder came in in 1889, and new breech mechanisms for quick-firing guns; and between 1890 and 1892 the manufacture of armour-plate was started, and hydraulic forging presses of 2,000 and 5,000-tons pressure were built. The Gruson Works, near Magdeburg, where guns and turrets are constructed, and another proving ground, were purchased at the same time; and in 1896 the management of the Germania Yard was taken over, the whole being completed by the actual purchase of the yard this year. The sole proprietor of all the establishments is Herr Friedrich Alfred Krupp. These facts are interesting, because, though no description of the Essen or Magdeburg Works is intended here, it will, of course, be understood that from these establishments come the guns, armour-plates, and many large steel castings and forgings



ENGINES OF THE RUSSIAN ARMOURED CRUISER "ASKOLD."



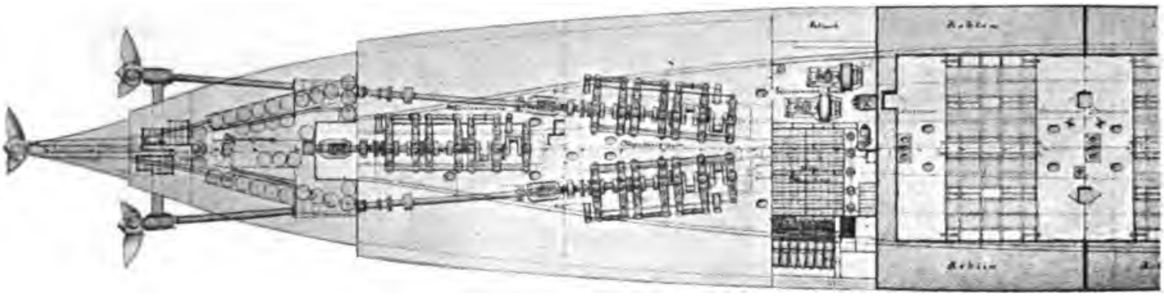
THE RUSSIAN ARMOURED CRUISER, "ASKOLD."

necessary for the ships built at Kiel. The number of employés at the whole of the establishments is close upon 40,000, while the total number of men, women, and children who depend upon the work provided is estimated at nearly 150,000.

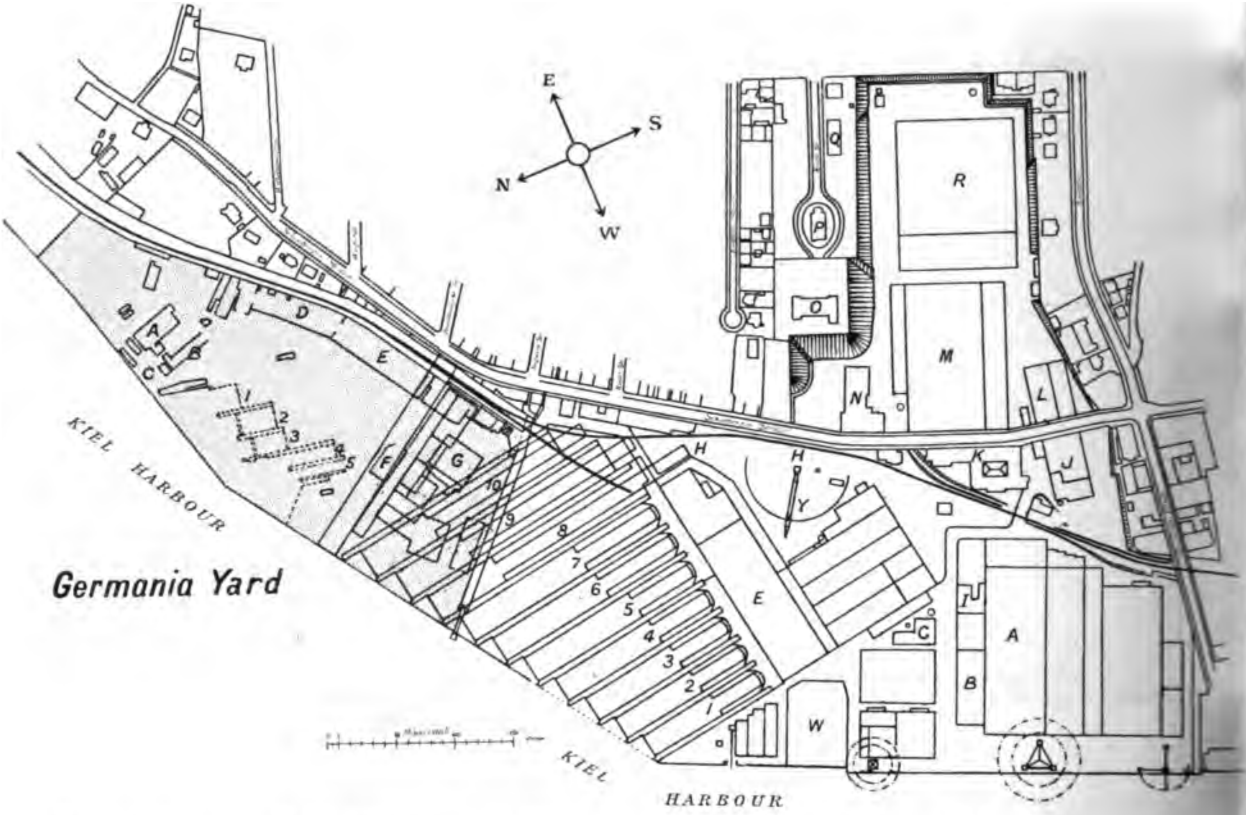
Although the machine and boiler works at Tegel, near Berlin, in which about 1,000 workmen are employed, are provided with complete equipment for constructing the most powerful machinery, with great steam hammers, fitting shops, erecting shops, and everything that can be required, it is intended, for the greater facility of work, to transfer them wholly to Kiel. The boiler shop was removed about two years ago, and by this time other parts of the establishment have been transferred. This concentration will conduce to economy and rapidity of work, which appear to be two great points kept in view by the firm.

THE OLD GERMANIA YARD.

The old Germania Yard at Kiel, which has accomplished a great work for the German navy and some good things for other navies also, had a frontage upon Kiel Harbour of about 440 yards, reaching from the Imperial Dockyard in the direction of the harbour. It



PLAN SHOWING PROPELLER ARRANGEMENT OF THE "ASKOLD."



Germania Yard

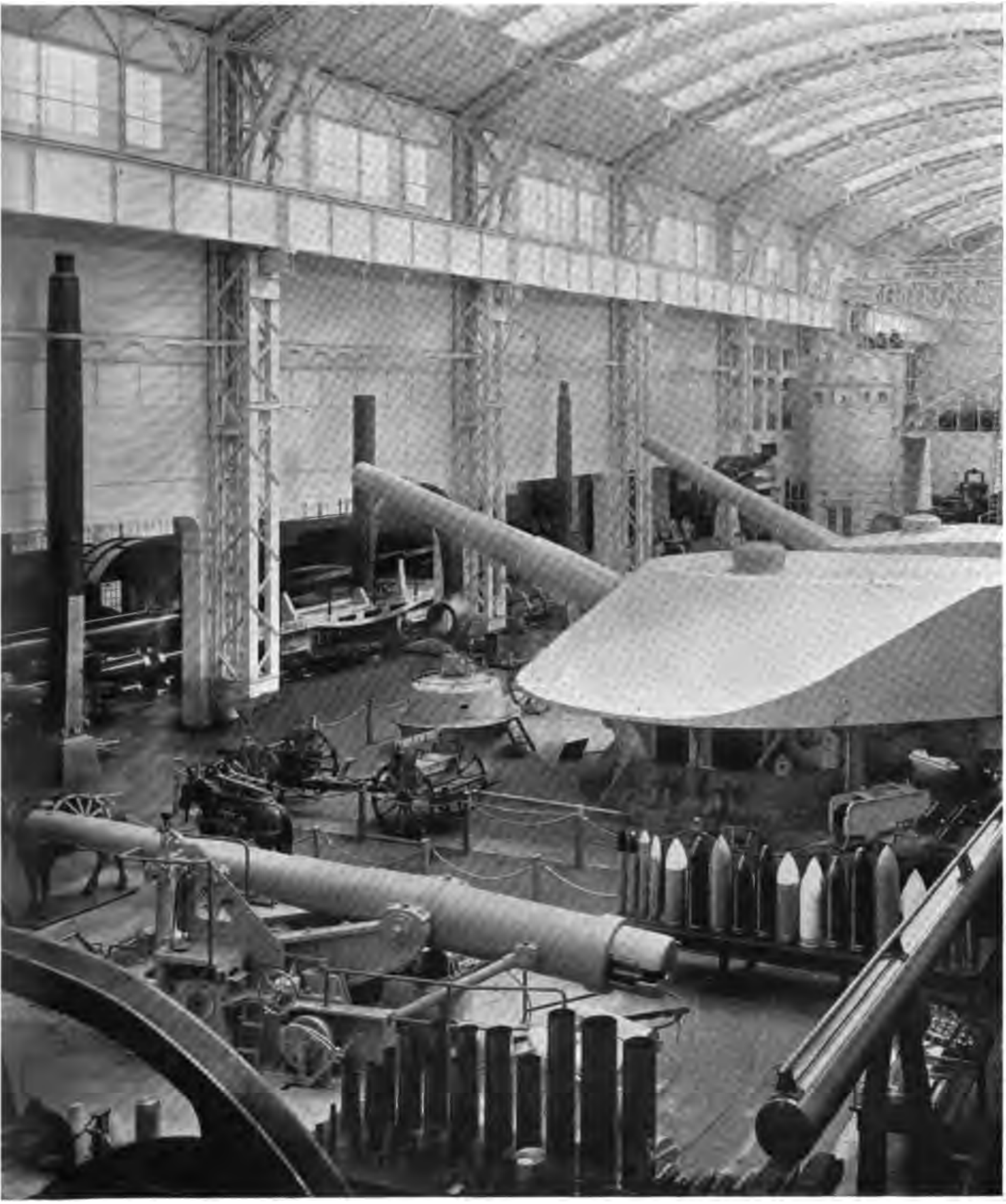
A	Erecting Shop.
B	Copper Smithy.
C	Boiler House.
D	Smithy, etc.
E	Ship Plates.
F	Experimental Room.
G	Smithy.
H	Yard Railway.
I	Testing-room.
J	Forge.
K	Offices.
L	Model-room.
M	Boiler Shops.
N	Central Power Station.
O	Workmen s Dining-room.
P	Church.
Q	School.
R	Iron and Bronze Foundry.
W	Torpedo-boat Slip.
Y	Cantilever Crane.
1–10	Building Slips

NOTE: Shaded portion shows area of the *old* yard.

extended a considerable distance inland, being bounded by the railway line on the south-east. Near the entrance was the block of offices and the model-room, with a photographic studio. There were five building slips, constructed upon piles, and four vessels more than 328 ft. long could be constructed. The last vessel to be laid down there was the new battleship "H," which was put in hand in 1901. Some additional facilities are being added in this part of the yard for the building of small vessels. These building slips in the old portion lie adjacent to the offices, shops, forges, stores, plate works, and other necessary establishments. There is a provision of 178 machines and machine tools, with 6 hammers of striking weights up to 1 ton. There are also 46 electric-motors, applied to all kinds of work, with many small steam engines and two Diesel engines. For lifting heavy weights are 19 cranes on various systems, with travelling gear, lifting up to 60 tons. A great fire took place in April, 1899, which did great damage to the old yard. It was traced to a short circuit in the electric wiring, and spread with great rapidity. The building slips were endangered, but by the assistance of officers and men of the Imperial Navy the flames were got under, though not until a great part of the works had been destroyed. Operations were much delayed, but the large liner *Kaiser Wilhelm der Grosse* was carried forward energetically and was launched within a month of the fire, thus keeping within the term stipulated.

SOME ACHIEVEMENTS.—THE "ASKOLD."

For the German navy, the old Germania establishment has built three battleships: the *Wörth* (10,000 tons), *Kaiser Wilhelm der Grosse* (11,000 tons) and *Zähringen* (11,800 tons), the latter now going through her trials; while, as has been said, the "H" (13,000 tons)



GUNS, GUNHOUSES, ETC., IN THE KRUPP PAVILION AT THE DÜSSELDORF EXHIBITION.

ELECTRIC LIGHT AND POWER STATION.

of the new and larger class is in hand. The *Baden* has also been rebuilt there. The *Siegfried*, of the coast defence class, was also constructed in the Germania Yard, as were the large cruiser *Kaiserin Augusta*, and a number of smaller cruisers—the *Prinzess Wilhelm*, *Greif*, *Blitz*, *Meteor*, *Gazelle*, *Nymphe*, and *Amazone*, with torpedo-boats, steam launches, and other vessels. Vessels have also been built for the Russian, Brazilian, Spanish, and Ottoman navies. Perhaps the most interesting of all those completed is the Russian five-masted protected cruiser *Askold*, of 6,000 tons. She was constructed to carry heavy ordnance and a thick armoured deck, with light displacement, and the speed was not to be less than 23 knots. There was competition in the design between the Germania Yard and the German firms of Schichau and Howaldt, the Ansaldo Yard at Genoa, and the Russian Nevsky Yard. The result was a great success for the Germania establishment, for the cruiser answered all expectations, and attained a speed of 24 knots. She is provided with Schulz boilers of 19,000 i.h.p., and has three screws advantageously disposed, the middle one in the keel line of the ship, and the others having a slight lateral inclination outward. The work of the Germania Yard has not been confined to warships. Mercantile steamers and liners have been built there, including the Lloyd steamers *Bonn* and *Halle*.

EXTENSION OF THE YARD.

The undertaking given by the German Government that all the new ships for the navy should be built in German yards and of German materials led immediately to the investment of new capital and to larger enterprise in the shipbuilding establishments, and the Germania Yard, like the Weser Yard at Bremen, the Vulcan Yard at Stettin, and the Schichau Yard at Danzig, were all developed in consequence. Excellent as were the arrangements in the Germania establishment, they did not altogether answer to the new conditions, especially in regard to the increased size both of warships and liners. It was recognised that by increasing the establishment and concentrating at Kiel the machine and boiler works removed from Tegel, work would be expedited and economy attained. An arrangement was therefore entered into with the Navy department that some of the land of the old yard should be transferred to the Imperial yard, which was its neighbour on the north-east, while the Germania establishment secured new land on the south-west on the inner part of Kiel Harbour. Much private land was bought, and an additional water frontage of about 875 yards was secured, with an area of some 58 acres. A great deal of excavation and clearing was required, and it was necessary to elevate some part of the land.

THE NEW YARD.

The large building slips are the most important features of the new establishment. Of these, ten are planned, but only seven have so far been built. Their length is from 377 ft. to 640 ft., with a breadth of from 85 ft. 4 in. to 98 ft. 6 in. The three others will be still larger, one being intended to have a length of 836 ft. These slips are built of concrete, with granite walls, and are closed by pontoons. Four of them are completely covered with glass roofs and sides, so that the work can go on in advantageous conditions, whatever may be the state of wind or weather. They are lofty, with sufficient head room, and are provided with the latest appliances. Each has two overhead travelling cranes worked by electric motors, and capable of lifting six tons. They can thus convey heavy fittings to any part of the ships in hand. It is expected that the covered slips will enable the period in which ships remain in hand to be shortened, and there will be material advantage in vessels being constructed under cover from the weather. It is intended that the other docks shall be covered in the same way. A large building slip, on which five or six torpedo boats of from 400 to 500 tons can be built, has also been laid out; it is of special character, with an unbroken slope carried below the water level.

Work is now actively in progress upon completing the new establishments of the Germania Yard. The various forges, shops, and stores are, and will be, closely adjacent to the slips, the arrangement being better even than in the old yard. There are smithies, with zincing plants, a fitting shop, a frame-bending floor, a drawing loft, an angle iron shop, a saw mill and carpentry shop, a joinery and painters' shop, tool shop, iron and metal foundry, model-making shop, boiler shops for cylindrical and water-tube boilers, and various forges, a copper smithy, a mechanical shop, a testing station for machines and boilers, a plateyard with a great cantilever crane, a central station, and three boiler plants. In planning the new buildings, provision has been made for possible extensions in the future. At present the works dispose of 914 machine tools and other machinery, 10 steam hammers of great power, 72 cranes, of which one on the wharf will lift as much as 150 tons and has a great overhang, and 260 dynamos and electromotors. The railway and the narrow line in the yard offer great facilities for the conducting of work. The yard has a very extensive electric plant, providing power and the current for 450 arc lamps and 4,400 incandescent lamps. There is also a complete telephonic equipment; and, indeed, it may be said that in all respects the Germania Yard is well abreast of the time, and fitted with the latest apparatus and every facility. The total number of workmen employed is at the present time about 4,000, but when all the new constructions so far planned are in working order, employment will be given to about 7,000.

But enough has been said. The Germania Yard may be described as a great fruit of German naval expansion. It illustrates how naval policy and the industries that are concerned with naval production react upon one another. The State provides a certainty of continuous work, and establishments are developed which answer all its requirements. The advantage to the nation is therefore twofold, and certainly Germans have reason to be proud of their Germania Yard, which is now an establishment probably as efficient as any other in the world. Its rise, development, and present position among great industrial undertakings, deserve to be well known in this country.

WORKSHOP PRACTICE

A RÉSUMÉ OF MACHINE TOOLS, CRANES, AND FOUNDRY MATTERS FOR THE MONTH.

MACHINE TOOLS.

AMONG recent machine tools, the premier place must be accorded to a heavy motor-driven grinder just brought out by the Landis Tool Company, represented in England by Messrs. C. W. Burton, Griffiths and Co., of Ludgate Square, E.C. Besides being one of the largest machines of this general pattern yet made, it possesses a good many novel arrangements. As it has not yet been illustrated, no apology is necessary for describing it at some length. Front, back, and side views are shown in the accompanying photos. The size of the grinder may be inferred from the fact that it swings 26 in., with a length of 12 ft. 6 in. between centres. Its wheel is 30 in. in diameter, by 2 in. thick. The weight without the motor is 14¼ tons. It requires a floor space of 18 ft. by 5 ft., and from 20 to 30 h.p. are required to drive it. This machine is of a semi-universal, self-contained type. By this we mean, first, that it does not contain all the adjustments of the Universal machines, and, secondly, that it is run without overhead works. As shown in these figures, it is arranged with a swivelling headstock, which has an adjustable spindle bearing, and is adapted for the use of a face plate and chuck, with which work can be ground at all angles from zero to 90 degrees. Provisions are embodied in the machine for the application of an internal grinding attachment when required, so that both straight and taper holes can be ground.

The headstock spindle runs in adjustable bearings, and can be locked, and the work revolved on a dead centre by a loose face plate,

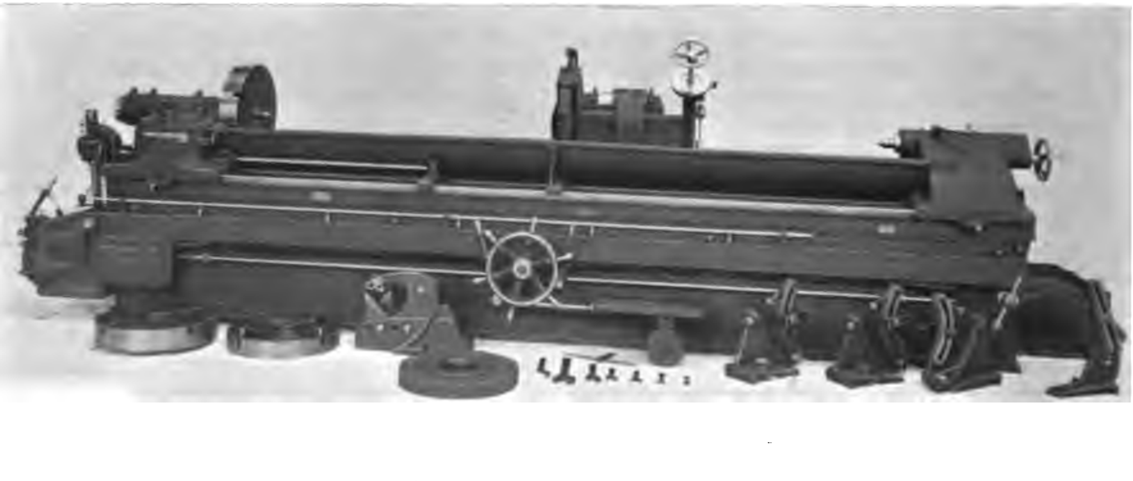


FIG. 1. LANDIS GRINDING MACHINE. FRONT VIEW.

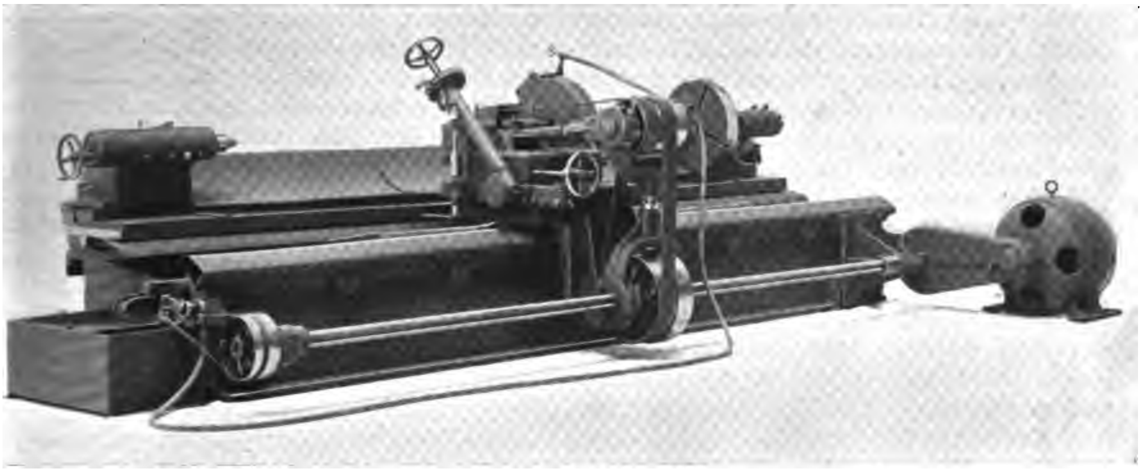


FIG. 2. LANDIS GRINDING MACHINE. BACK VIEW.

in a similar manner to the smaller machines manufactured by this firm. Its journals measure $4\frac{7}{8}$ in. by 12 in. and $4\frac{7}{8}$ in. by 8 in. The swivelling head is dowelled for a straight line position with two taper pins, and is secured to its base by three heavy bolts in a circular tee slot. The interior of the headstock is fitted with bevel gearing, which operates concentrically with the pivot of the swivel, by which the power is transmitted to the work driving arrangement thereon at all angles. A shaft extending from the end of the swivelling table of the machine to some distance towards its pivot passes through the base of the headstock. This shaft is splined, and on it a gear is mounted, having a spline engaging a key-way, so permitting the head to be moved to different positions as required. A lever on the front of the same is arranged to engage and disengage the gearing from the shaft by a clutch, for the purpose of stopping the work independently of the traverse, a feature which is very desirable.

The footstock spindle has an adjustable bearing, and it can be clamped. It is operated by a screw, which is back-geared to a hand-wheel. It measures $4\frac{7}{16}$ in. diameter by 24 in. long. Both head and footstock are massive, and are traversed on the table by a rack secured to the latter and a pinion on each head, which is operated by a detachable crank, the necks for which are seen under the head in fig. 1. The centres of head and footstock are $2\frac{3}{4}$ in. diameter.

The emery wheel base is fitted with a heavy spindle, with journals measuring $4\frac{7}{8}$ in. by 15 in. and 4 in. by 10 in. It carries an emery wheel 30 in. diameter, by either $1\frac{1}{2}$ in. or 2 in. wide, two wheels being supplied. The driving pulley is 14 in. diameter for a $4\frac{1}{2}$-in. belt, and gives ample power for doing rapid and heavy work. The bearings are adjustable, and their large size reduces the wear to a minimum. The base is adjustably mounted on a slider, which works on a lower slide with large bearing surfaces.

Power for driving the emery wheel is transmitted through a grooved shaft running the whole length of the machine on the gear side (seen in figs. 2 and 3). A pulley which is trunnioned in a bracket secured to the emery-wheel carriage passes to and fro along the shaft, and is driven by the grooves in the shaft through wheels, thus ensuring a practically frictionless travel. A vertical yoke carrying an upper intermediate shaft and pulleys serves as a joint to another yoke connecting with the emery-wheel base (figs. 2 and 3). This makes a complete connection between the lower shaft and the emery-wheel spindle, and compensates for the movement of the emery wheel to and from the work, keeping the driving belts in tension. Both yokes are provided with screws to lengthen them, in order to tighten the belt as required. It will be noticed that this driving mechanism produces no pull on the carriage guide, nor against the wheel feeding device by the power transmitted to it, the force due to the belt pull being all taken up in the yokes themselves. This leaves the carriage free to move, and to carry nothing but its weight, and the grinding cut. Two-stepped cones give two speeds to the wheel from the shaft. The emery-wheel carriage runs in guide ways on the bed, which are scraped to surface plates. These guides are completely protected along their entire length by metallic covers.

From the rear shaft on the machine at the headstock end (see fig. 3), motion is transmitted to the gearing for revolving the work, and traversing the emery-wheel carriage. This arrangement consists of a cone pulley on the rear shaft which is loose on the same, and secured when required, to drive the work, and feed by a friction clutch. This clutch is operated by a rod on the front of the machine, seen in fig. 1, making it convenient to stop and start the same from any position occupied by the operator in front, being a device similar to that adopted on heavy lathes. The cone pulley connects to the gearing referred to, by a belt, and is used for changing the speed of the work. There are four changes of speed by the cone pulleys, and, in addition, a back gear, which makes four more, and these, together with a change made by a lever at the headstock, admit of 16 speeds, ranging from 8 to 200 revolutions. The change of traverse feed is made by a lever shown on the gear box at the left hand, or headstock end of the machine (see fig. 1), by which cone gears, arranged with suitable speeds, are positively clutched to the shaft, giving five changes, from $\frac{3}{16}$ in. to 2 in. per revolution of work. The automatic cross feed ranges from ·00025 in. to ·008 in. at each reversal of the carriage.

The hand wheel carriage is traversed on the front of the bed with the emery wheel, and on it is located a lever for starting and stopping the traverse feed, and another for reversing the motion of the carriage by hand; also a hand wheel by which the carriage can be moved by hand to a limited amount. This hand wheel has a clutch, so that it can be disengaged while power feeding, to avoid its turning. To the carriage is attached a platform which is mounted on wheels, and carried back and forth, permitting the operator to stand and look over his work. This arrangement is desirable in consequence of the size of the machine, and of the work that can be done on it.

The long table on which is located the head and foot-stocks is pivotted at its centre, enabling

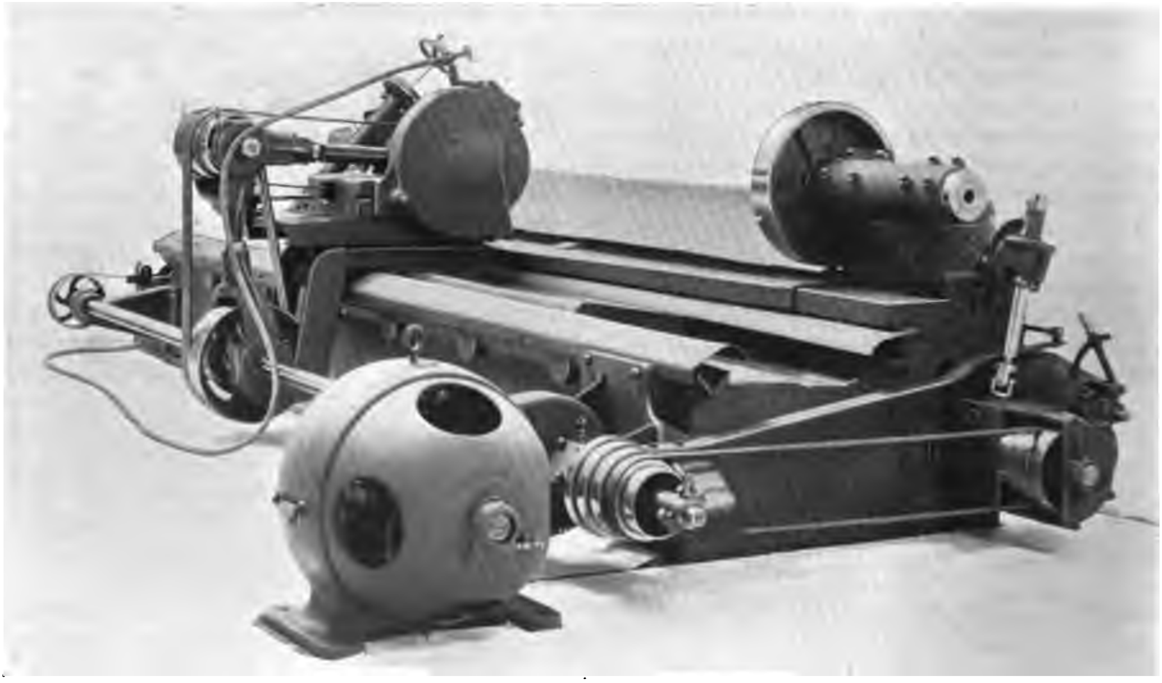
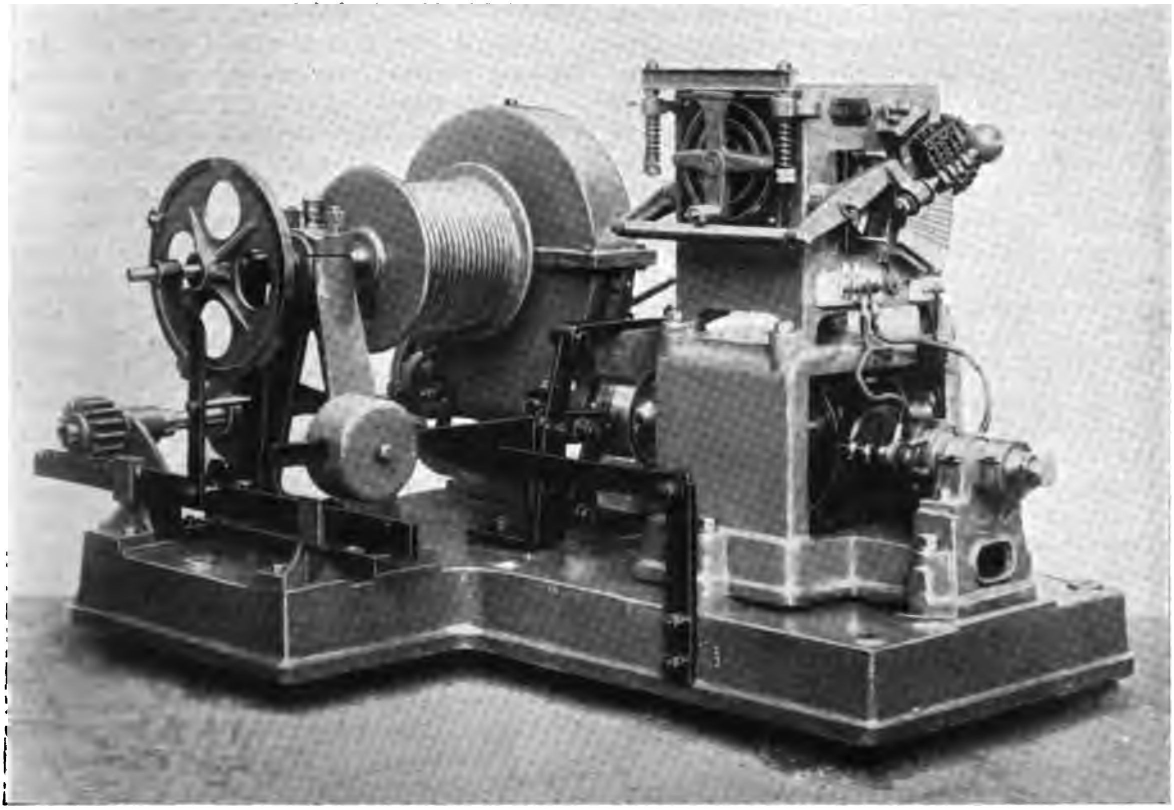


FIG. 3. LANDIS GRINDING MACHINE. END VIEW.



RECENT ELECTRICAL WINCH. BY THE LAHMEYER ELECTRICAL COMPANY, LTD.

tapers up to 2 in. per foot to be ground. A graduation on the end of the same gives the readings by which it can be set. It is firmly clamped at four points in its length. In swivelling this table, universal couplings on the vertical shaft at the left hand end of the machine (figs. 1 and 3) compensate for this movement. The pump for lubricating is seen at the left hand of fig. 2. All the gears are protected from dirt, as well as from possible danger to the operator. The screws are covered in, and protection to all bearings is fully provided. The parts are very massive, as will be noted.

This machine is also built when required without a swivelling headstock, a plain fixed head being substituted, so making the machine a plain grinder, which would then serve for grinding shafts on their centres, both straight and tapered. For the finishing of many pieces this is all that is required. Power can be supplied to the machine either direct from the shaft by belt, or by electric-motor, coupled with driving chain, as shown by the illustration.

THE FOUNDRY.

A remarkable feature in the iron and steel trades is the present inflation of prices, both in England and America. Although the output of the United States has beaten all previous records, yet it is impossible to supply the demands of the present, and of the immediate future. In 1901 the output of pig in the States was 15,878,354 tons, more than twice as much as that of the United Kingdom, and an advance of more than 2,000,000 tons on the output of the year previous. Yet the railways are blocked with ore and coal, and deliveries of pig are being booked for 1903 at from 18 to 22 dollars per ton, and shipments are being made from Glasgow and Middlesbrough to the States. Concurrently with the increase in production, there is a greater demand for iron and steel, and this becomes a corrective to the pessimistic views which have been entertained respecting the effect of American competition on British trade, and the rivalry of the Steel Corporation in particular. In thirty-three years (from 1867 to 1900) the consumption of iron per head of the world's population has advanced from 20 lbs. to nearly 80 lbs. The United States absorbs 400 lbs. per head—an amount five times greater than the world's average. The bridges and tall buildings absorb nearly half the quantity used in the States. The growth of the American iron and steel industry need not, therefore, be a menace to British trade, if full advantage is taken here of labour-saving appliances.

Labour, moreover, is cheaper here than in the States, which is a point in our favour. High wages and cheap production are reconciled there to an extent which has not been attained in any other country. Though wages are high, the output per man is enormous. At the Edgar-Thomson blast-furnaces only 1,600 men are employed for an output of 24,500 tons per week, giving an average of 795½ tons per man per annum. At the Homestead steel works the wages bill runs to about £2,400,000 a year. The average earnings are about 11s. 3d. per day, but those of rollers and heaters run to about 62s. 6d. per day. In a year 2,000,000 tons of steel are turned out, of which one customer alone takes 1,000 tons daily. The standing charges in such an establishment must be lighter than they can possibly be in any British establishment. Wages are so good that men are independent of the unions. A recent report shows that while in Great Britain at a recent date there were 1,905,000 trade unionists, there were only about 1,600,000 in the United States and Canada, for about twice the population. Two other facts are helpful to the energetic workman—the encouragement of invention and the ease with which the best men can become employers. There is also an immense scope for men who desire to improve their position, apart from the iron and steel works. There are 4,600 foundries in the United States: of these, 646 are in the State of Pennsylvania, 515 in the State of New York, and 400 in Ohio. These are the great centres, the numbers being fewer in other districts.

CRANES.

Motor driving is now shared about equally between overhead travellers and winches. There are no other types of hoisting machinery (lifts excepted) to which electricity has been applied so extensively as in these. The reasons are that steam is very objectionable in many cases, and that electric energy is already available in others. In mining work especially, the electrical winch has largely replaced the steam-driven machine, dividing favour with compressed air; but the electric system is generally higher in efficiency than compressed air. A steam winch is nearly always noisy and dirty; an electrical winch, on the other hand, is clean, comparatively quiet, and ready for instant service. It is also capable of dealing with short overloads, without pulling up, as in the case of a steam winch. The electrical winch has not yet become standardised to the same extent that steam winches have, different makers having adopted various designs.

We illustrate a recent electrical winch by the Lahmeyer Electrical Company, Ltd., of Frankfurt-on-Main, and 109, New Oxford Street, London, the principal features being as follows: The drum is driven by a large worm wheel operated by a worm on the motor shaft below. The controller is mounted above the motor frame, rendering the hoist more compact. Everything is carried on a single cast-iron base. The brake acts on the coupling between the motor and the worm. The controller works automatically after the motor is started; after the switching in, the resistance is gradually cut out by means of the weighted lever seen to the right of the controller. To this lever is attached insulated carbon and roller contacts sliding over vertical fixed resistances. To prevent this resistance from being cut out too quickly, the outer end of the lever is attached to a bar which acts against the springs, through a cross-bar seen in front of the box. In other cases a dashpot filled with glycerine affords the necessary resistance. On stopping the motor by bringing the switch to the "off" position, the resistance lever is brought back to the position ready to start the motor again. The controller is operated from the winch through pitch-chain wheels, not seen on the far side of the photo, a portion of the body of the chain only being visible.

THE DEVELOPMENT OF "WIRELESS" TELEGRAPHY.

BY

H. C. MARILLIER.

In this article the author deals with a number of inventors whose work has not yet attained to the range of prominence of Signor Marconi's.*

III.

HAVING dealt with the early history of "wireless" telegraphy, and with the part played by Mr. Marconi in its development, it remains to give some account of other systems which are in working or which have been proposed. The most important rival to the Marconi Company at the present moment, in point of growth and influence, is the Allgemeine Elektricitäts Gesellschaft, of Berlin, which has acquired the patent rights of the Slaby-Arco system, and is contesting the field of maritime communication. Backed by the paternal German Government, it has succeeded in getting its instruments installed in the German fleet, and also on board some of the ships of the North German Lloyd and Hamburg-American lines, notably the *Deutschland*, belonging to the latter line. Owing, however, to the Marconi contract with Lloyds' stations, vessels fitted with the Slaby-Arco apparatus are debarred at present from communicating with those points in other countries, and this reservation no doubt operates unfavourably against them. The maximum distance over which the Slaby-Arco system has been successfully worked seems to be 150 kilometres, which was the recorded limit of signals exchanged between the *Deutschland* and the Hamburg-American station at Duhnen, near Cuxhaven. The *Deutschland* carried an aerial wire thirty-two metres long.

THE SLABY-ARCO SYSTEM.

Professor Slaby, and his assistant Count Arco, began experiments in 1897 after first visiting the British Post Office installation set up by Marconi at Lavernock Point, in the Severn Channel. Availing themselves of permission to use the imperial grounds near Potsdam, they carried out a long series of investigations over an average distance of three kilometres, using the castle on the island of Pfaueninsel as one base, and a church tower at Sacrow as the other. Wires were suspended from the tops of these two eminences and were supported down the walls on insulators. Surrounding trees,

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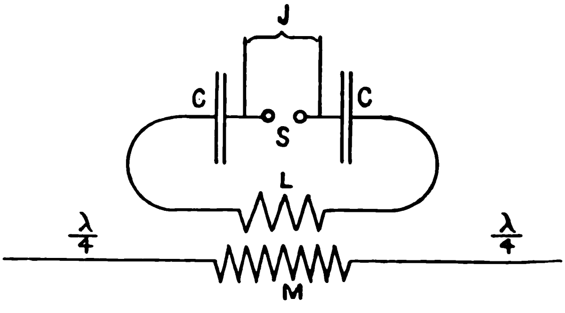
* The Marconi System was described and illustrated in the October issue, the series having been commenced in the September issue with an account of pioneer work in the field of "Wireless" Telegraphy. An article on this subject, contributed to the August number by Sir William H. Preece, K.C.B., F.R.S. (late Engineer-in-Chief and Electrician to the British Post Office), described his relations with Signor Marconi, and discussed the present value of ætheric telegraphy as a commercial system.

PROFESSOR A. SLABY.

passing barges, and other obstructions interfered with the experiments, which were on the whole, of a rudimentary nature. They are described in detail in a paper read by Dr. Slaby in November, 1897. In December, 1900, Dr. Slaby read another paper on the subject, in which further developments were recorded. The point upon which these investigators have always insisted, is that the receiving wire should be tapped by the coherer at the point of maximum oscillations. Their researches have been largely devoted to this end, and it seems to contain the essence of whatever differentiation may be claimed for their system. Moreover, as the location of such points is fixed and corresponds to certain definite wave lengths, it suggests a means of tuning and screening two stations so that the instruments are not confused by alien signals. The transmitter consists of an aerial wire suspended from a flag-pole on a building, and earthed to the water pipes below. At one point it is brought through a window into the neighbourhood of a powerful induction coil. The opposite terminal of the coil is earthed through a condenser, and an adjustable self-induction coil, which is used for tuning the oscillations in this part of the circuit to those in the aerial wire. To increase the wave length in the wire it is necessary to switch in one or more subsidiary coils, which correspond to a stretch of wire necessary for increasing the wave length by one-quarter each time. The receiver consists of a corresponding aerial wire earthed, which is tapped at a point of maximum oscillations. The oscillations are further reinforced by a resonator or "multiplicator," which is connected direct to the coherer. The other end of the coherer is earthed through a battery and relay circuit, across which is shunted a condenser. This part of the apparatus, together with the tapper, or decoherer, is practically the same as that employed by Marconi, and earlier still by Sir Oliver Lodge. Full descriptions of the apparatus employed are issued by The Elektricitäts Gesellschaft, with a list of the parts comprised in each portion of the transmitting and receiving circuits, and diagrams of the various sections. The primary transmitting circuit comprises, in addition to the induction coil and Morse key, a mercury-turbine interrupter, which is replaced in long-distance installations by a Grisson continuous-current alternating-current transformer. The secondary circuit contains a Leyden jar battery of 3, 7, or 14 jars, a spark gap, and sundry tuning coils. The receiver contains no special features beyond what have been mentioned. Vacuum coherers are employed. In addition to its ordinary signalling apparatus, the company manufactures a portable set for field use. The employment of lightning conductors, and other handy vertical conductors, forms an element in its schemes for emergency use.

BRAUN-SIEMENS-HALSKE SYSTEM.

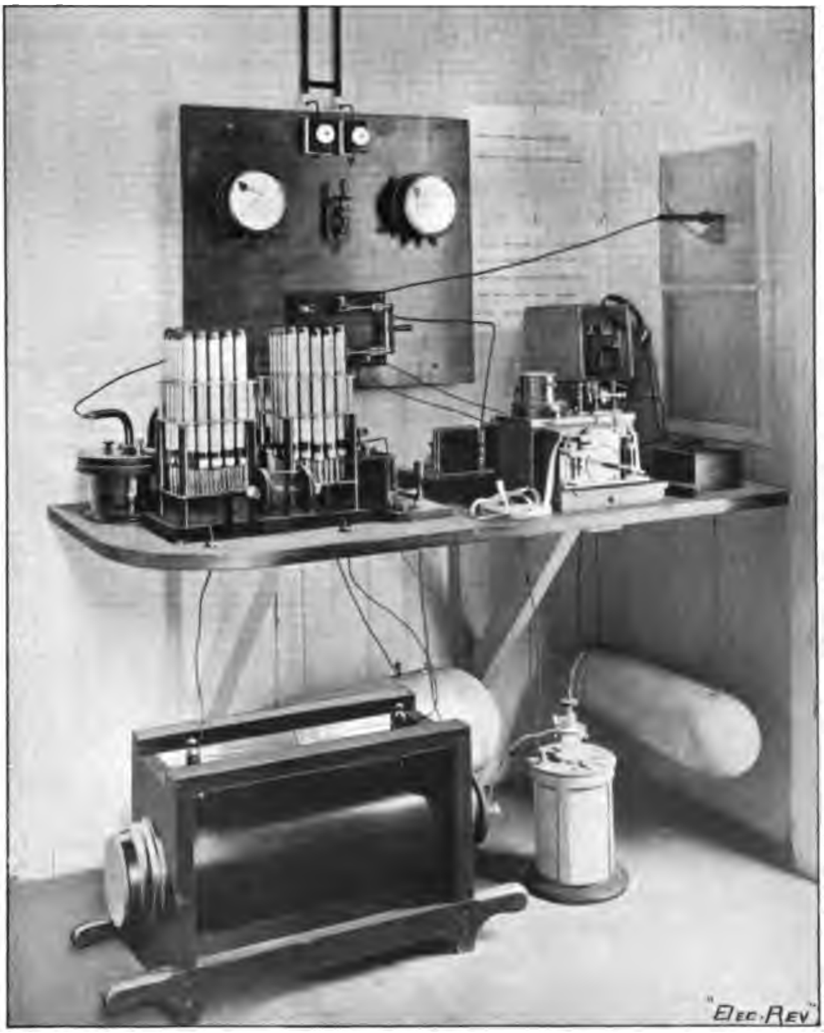
The other great German electrical firm of Siemens and Halske have acquired the patent rights of a system devised by Professor F. Braun, of Strassburg. This is a closed circuit system, in which the oscillations set up by an induction coil are reproduced in a secondary coil,



From the *Electrical Review.*

FIG. I. BRAUN-SIEMENS-HALSKE TRANSMITTER.

M (fig. 1), in such a way as to raise the intensity very considerably. The circuit containing the secondary coil is an open one, consisting of a length equivalent to one-quarter the wave-length employed on either side of the coil. One of these lengths forms the aerial wire, the other is either coiled or replaced by a suitable capacity. Signor Guarini, in a description of the system,* says: "The transmitting apparatus consists essentially of two groups, the induction coil with its auxiliaries, and the circuits of oscillation. The former differs considerably from the ordinary type in construction, its aim being to produce not so much the high pressure of the ordinary spark as a large current output. With this special coil one is able to charge much larger capacities in a shorter time interval than was possible with the ordinary form. The practical difference in construction consists in employing a special iron core, a considerably larger primary, and a much shorter and heavier wire for the secondary than in the ordinary type." The primary is made interchangeable, and fitted with three terminals giving different lengths of primary for different interrupters.



From the *Electrical Review.*

GENERAL ARRANGEMENT OF BRAUN "WIRELESS" TELEGRAPH STATION.

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* *Electrical Review*, Sept. 26th, 1902.

Owing to the strength of current used, a specially modified Morse key is introduced capable of interrupting a current of 50 ampères without injury. A "Wehnelt" interrupter, and for large installations a Grisson direct-current alternating-current transformer is used. By the courtesy of the *Electrical Review* we give herewith a general view of a Braun "wireless" telegraph station, showing the form of Leyden jar batteries employed. The round-ended cylinder suspended on the right is the form of capacity used to replace the open wire which balances the aerial in the secondary circuit of the transmitter. Professor Braun's patents were mostly taken out in 1899, and his system in its earlier stages was described by him in a paper read before the Physical Institute of the Kaiser Wilhelm University. Experiments have been carried out with it for some time past between Cuxhaven and Heligoland, a distance of 36 miles.

THE BATTLE OF THE SYSTEMS.

It may seem curious that so much effort and rivalry should be expended on competing systems still at this stage, when the Marconi Company is claiming to have established records in thousands of miles, and is confidently building huge stations for signalling across the Atlantic. The high rates and royalties charged by the Marconi Company, as well as an uncertainty about the actual results, are a main factor in this apparent anomaly. Every government is on the watch for a practicable system of "wireless" telegraphy, especially for naval purposes, and most of them consider the Marconi system prohibitive at the price. The American Government has experimented with many systems, on a specially chosen site between Washington and Annapolis. It has tried successively the Slaby-Arco, the Braun-Siemens, the Ducretet, the Rochefort, and other patent systems, including also those of Prof. Fessenden and the other American inventors who are in the field. They are now said to be experimenting with an Armstrong-Orling installation. Most other Governments have probably done, or are doing the same.

"WIRELESS" TELEGRAPHY IN THE NAVY.

Our own Navy was equipped a year or two ago with Marconi apparatus, but the screening or tuning devices notoriously failed at the autumn manœuvres when they were first tried, and the signals were communicated impartially to friend and foe. The British navy, however, possesses in Captain H. B. Jackson, F.R.S., an able and early experimenter in "wireless" telegraphy, who has himself devised a successful syntonic system. Captain Jackson has made several modifications in the naval apparatus, and is believed to have simplified it considerably, although details of his work have not been published. In May, 1902, he read a paper before the Royal Society, "On some Phenomena affecting the Transmission of Electric Waves over the Surface of the Sea and Earth," which represent the first exact data, so far ascertained, as to the intercepting influence of different obstacles. For instance, testing the screening effect of different kinds of rock, he has established that (1) soft sandstone, shale, etc., (2) hard limestone, (3) iron ores, transmit waves in the ratios of 72, 58, and 32 per cent. respectively. He has also made lengthy tests of the effect of barometric disturbances on the signalling distance, and finds, contrary to what Mr. Marconi has frequently stated, that an electrical state of the atmosphere generally causes a diminution of signalling effectiveness, although in one case at least it momentarily *increased* it by 50 per cent. Other valuable points of information brought out by Captain Jackson in his paper are that mist or dust-laden air—*e.g.*, the Mediterranean sirocco — will account for a diminution in the range of signalling; and that want of synchronism in the oscillatory discharge of the spark, when proper syntonic apparatus is not used, causes zones of cessation in signalling, rapid damping of the radiator being a contributory cause. The irregularity of the train of waves, it is supposed, gives rise to different types of disturbance at different parts of their path, in which case they may not have the necessary cumulative effect on the receiving circuit. Captain Jackson's researches are in marked contrast to the somewhat over confident optimism of other inventors, who are apt to claim that weather and obstacles make no difference whatever to their system, and that, in fact, bad weather is rather to be preferred. Mr. Marconi's observation when crossing to America, that signals were transmitted much more freely by night than by day has not so far been fully explained, but it is worth further investigation.

THE ORLING-ARMSTRONG SYSTEM.

Between most of the competing systems of "wireless" telegraphy, the differences lie chiefly in details. One inventor prefers to connect his coherer one way, one another; or the coherers themselves may be different; or there may be special devices used. But externally the systems in general are very much alike, and depend on the same principles of emission and reception of Hertzian waves. This is not the case with the Orling-Armstrong system which has lately been brought out. The difficulty in this case is to find anything in common with other systems. As no intelligible description has ever been given of the transmitting apparatus employed by Messrs. Orling and Armstrong, or of its action, one must perforce fall back upon the view taken by the inventors themselves and the journalists who have described their experiments, that it is "a new discovery," and treat the matter from this standpoint. In October, 1901, a demonstration was given at Hughenden, on the estate of one of the inventors, to which a number of pressmen were invited, and the writer was present on that occasion. The experiments were somewhat varied, and included the exchange of Morse signals across a pair of fields, the actuating of a torpedo rudder in a ditch, the lighting up of a lamp at a distance, causing a tiny lamp to glow without wire connections, and the wireless transmission of speech through a telephone. Owing to unfavourable weather and the sketchy nature of the programme, it could hardly be said that the experiments were conclusive; but they were undoubtedly interesting, and taking all that the inventors claimed for granted, extremely promising. The most remarkable fact about them was that not only were they performed without wire connections, but without poles or aerial wires of any sort, and with a simple Bunsen battery representing about 8 volts. The transmission, moreover, was not by means of Hertzian waves through the air, but of currents through the earth.

JAMES TARBOTTON ARMSTRONG AND AXEL ORLING.

AN UNREVEALED TRANSMITTER.

The method of earth currents is not in itself a new one. It was, as the writer showed in his first article, amongst the earliest devices tried by experimenters, and was superseded first by the induction method and then by Hertzian waves. Messrs. Orling and Armstrong, however, do not use earth currents pure and simple, but claim by means of a "make and break" induction mechanism, forming part of the unrevealed transmitter, to combine them with high tension discharges which vastly enhance their capabilities. The scientific explanation of this phenomenon is still to be given. Assuming that it is as the inventors say, the method of proceeding is to run a pair of wires from the terminals of the transmitter to two iron stakes driven into the ground, or to earth plates, some ten feet apart or more, according to the distance to be traversed, and to connect the

ORLING-ARMSTRONG CAPILLARY RELAY.

receiver in the same way. This simple arrangement provides all that is requisite for signalling, and even for verbal telephoning, up to five miles. For longer distances up to twenty miles vertical wires are employed, but with what effect is not explained. In really long distance signalling it was the inventors' intention to make use of relays buried in the earth at suitable intervals, and for these relays a novel and extremely sensitive instrument has been devised, the latest form of which, a mercury-capillary siphon, is the only piece of apparatus belonging to the system which has been technically described and illustrated. The inventors claim to have discovered what other investigators have missed or ignored,* viz., that however sensitive the ordinary filings coherer may be in its virgin state, this sensitiveness is greatly diminished after a current sufficient to work an ordinary relay has once been passed through it. The capillary siphon practically passes no current at all ; and the coherer used with it consequently preserves its sensitiveness indefinitely.

"ARMORL" ELECTRO-CAPILLARY RELAY.

We show here an illustration of the "Armorl" electro-capillary relay, and also a diagram of the receiving apparatus (fig 2), comprising a coherer, relay, and de-cohering device. The latter is reduced in powerfulness proportionately to the reduction in current passing, and is just sufficient to break the small arcs, or relieve the strain, between the cohering particles. The construction of the relay and its action are as follow: There is a bent-tube siphon of which the shorter leg stands in a vessel of mercury, and the longer leg goes over into a vessel of acidulated water. The point of this leg is so fine that mercury is prevented by capillary repulsion from passing out; but when even a minute current is sent through the leg and out from the water vessel, the mercury, as in Lippmann's electrometer, follows the current, and comes from the bottom of the siphon in extremely fine drops. These fall on to a globule of mercury sealing a very fine hole in the bottom

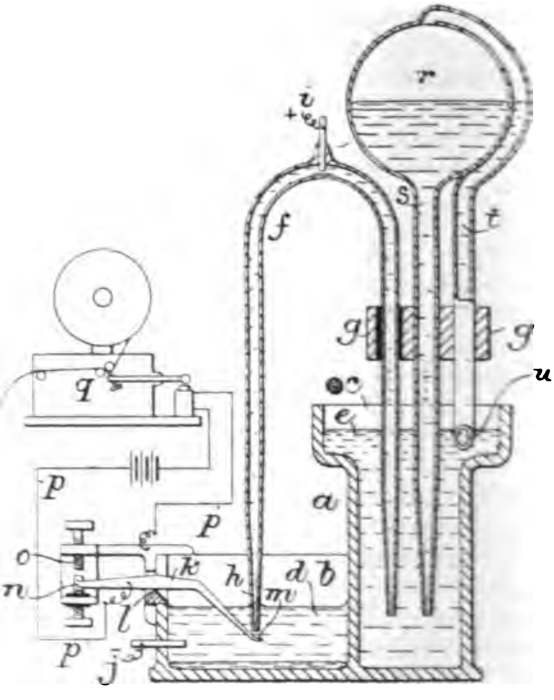

FIG. 2. THE ORLING-ARMSTRONG CAPILLARY RELAY—THE RECEIVING APPARATUS.

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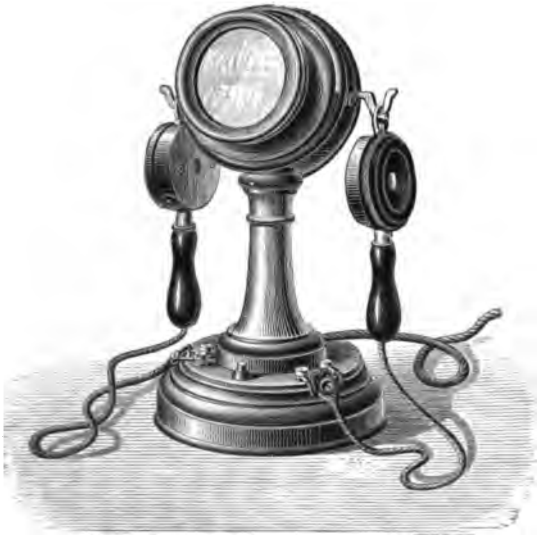
* Dr. Chunder Bose, however, in his paper on coherers read before the Royal Society, April 27th, 1899, pointed out the same fact as having been noticed by him.

of the water vessel, and their addition is sufficient to cause a corresponding flow through this hole. The droplets on passing out of the hole form a momentary contact between two metallic points, and so cause the relay or receiving instrument to act. After passing the contacts they next fall on to a small vibrating tongue in connection with the coherer, and so perform the function of de-cohesion. The writer has seen this instrument operated through a high resistance with an infinitesimally small current, and certainly its sensibility is beyond that of anything at present in use ; far beyond that of the siphon recorder, for instance, which it is well adapted to replace, quite apart from questions of "wireless" telegraphy. It should be mentioned that an ingenious form of automatic fountain is affixed to the relay, whereby the level of the mercury in the main vessel is kept constant.



THE ORLING-ARMSTRONG "WIRELESS" TELEPHONE.

THE INVENTORS OF THE ORLING-ARMSTRONG SYSTEM.

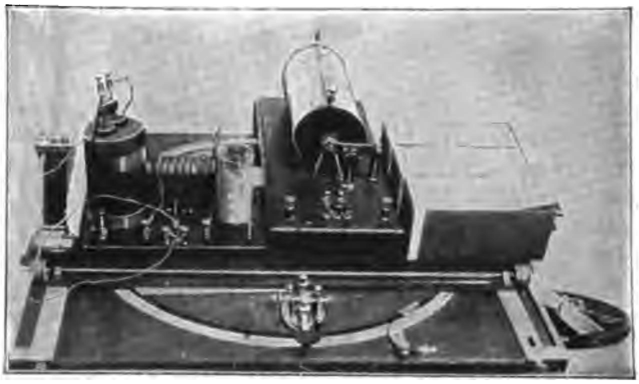
Mr. Orling, the actual inventor of this combination, is a young Swede whose experiments with a dirigible torpedo attracted some attention in his own country before he came here. He is an enthusiast, and a highly resourceful experimenter. Mr. Armstrong, his collaborator, is known as having sold the Lee-Metford patents to the British Government. The two have apparently formed a company with a capital of £175,000, already promised or subscribed, and are now engaged in manufacturing and selling instruments at an extraordinarily low cost. They have works at Hughenden, and in France, where they seem to have allied themselves with the Branly company, and the field for which they are specially laying themselves out is that of small private installations. They have also worked out an extremely light and portable apparatus for military use. The telephone here illustrated is the simplest thing so far produced and offered for wireless purposes. It is fitted, as may be seen, with four terminals, two of which go to a small battery, and two to metal spikes in the ground. It is guaranteed to reproduce speech up to two miles, and to serve for Morse communications up to five. For twenty miles a different apparatus is supplied.

SCREENING.

Nothing has yet been said about screening, one of the most vital points in connection with the Orling-Armstrong apparatus. In this the inventors claim to have a great advantage over users of long waves. By means of their interrupter and proper adjustment of the receiving instrument, it is stated that they can render any pair of instruments absolutely private, and that they have a range of 40,000 wave lengths on which to ring the changes. Inquiry elicited the information that ordinary instruments, such as the telephone apparatus shown, are not fitted with any such selective mechanism, and it will be interesting to see how they work in practice. It was added that in case of trouble arising on this account the modification could easily be made at reasonable extra cost.

DE FOREST SYSTEM.

Of other systems calling for notice by reason either of their originality or importance may be mentioned two that have made their appearance in America—the De Forest and the Fessenden. Both employ a different device from the ordinary coherer as the root of their receiving apparatus. In the De Forest system, use is made of what is known as the "anti-coherer" principle, namely, instead of the effect of the waves being to diminish a resistance and so start a current in the relay, they increase it and so cause an interruption in a normally flowing current. The De Forest "responder" is an electrolytic cell, in which two electrodes of



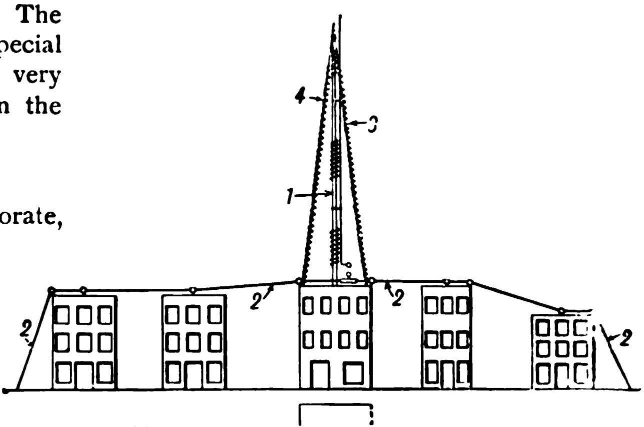
From the *Electrician*.

FESSENDEN'S APPARATUS.

some soft metal are placed in a viscous paste containing metallic particles and an electrolysable liquid. A current flows through this from a local battery, detaching minute particles of metal and causing them to pass from one electrode to the other, so that the normal resistance of the cell is small. Under the action of Hertzian waves electrolysis is set up, and the generation of hydrogen bubbles at the cathode forms a cushion which increases the resistance and breaks the current momentarily. The transmitting apparatus consists of a small alternator, giving an ordinary alternating current of about 500 volts, with a periodicity of 60 per second. This is transformed up to a potential of 25,000 volts, applied direct to a spark gap with a Leyden jar battery in shunt. The primary current is interrupted with a special Morse key, and signalling is said to be very rapid, averaging forty words per minute in the usual Morse code.

FESSENDEN'S SYSTEM.

Professor Fessenden's system is more elaborate, and claims to be based on a new principle entirely. The waves he uses are not Hertz waves proper, but "half-waves," which travel over the surface of a conductor and admit of being deflected. They are described as "semi-free ether waves, but yet not current waves,"[*] and in his specification Professor Fessenden says: "In the Lodge waves the electrical energy is maximum when the magnetic energy is minimum, and all the energy not absorbed by resistance is recoverable; with the form investigated by me the electrical energy is a maximum at the same time as the magnetic, and none of the energy radiated is recoverable except by deflection." The Fessenden transmitter is shown in diagram. It consists of a vertical aerial wire, called "the antenna," and a long secondary conductor which is carried horizontally over buildings, etc., and earthed at each end. The length of either arm of this conductor is approximately one-quarter the wave length employed. The mast is guyed from the top by coils, which have a natural period of oscillation different from that of the antenna; which arrangement, it is claimed, together with the earthed conductor, or "wave-chute," eliminates all outside interference from wave lengths not in tune. The vertical wire has a large capacity and a low induction, the former being regulated by increasing the area of the wire, and the latter by adding to the number of turns of wire which connect the vertical wire with the source of electro-magnetic force. The induction coil is kept permanently in action when transmitting, a key being employed to interrupt the flow of waves by throwing the antenna out of tune with the receiving station. The key short-circuits the tuning device. This latter consists of a tuning grid consisting of parallel strips or wires, immersed



From the *Electrician*

FIG. 3. FESSENDEN'S APPARATUS—THE "WAVE CHUTE."

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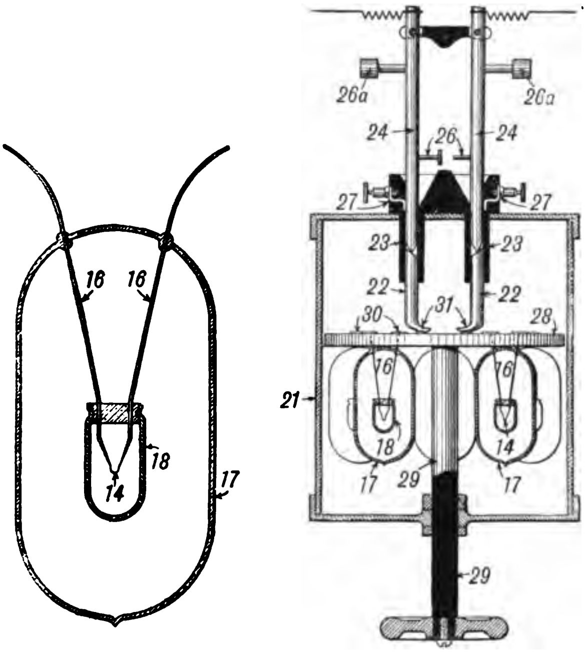
[*] See description by A. F. Collins in the *Electrical World* (N.Y.), August 23, 1902, and in the *Electrician*, October 3, 1902. The illustrations are kindly supplied by the *Electrician*.

in oil, and fitted with sliding contact pieces. The capacity and inductance of the tuning device are carefully proportioned to give a true sine wave.

The Fessenden detector or receiver is an ingenious device illustrated in the diagram. A minute loop of silver-plated platinum wire (marked 14 in the diagram illustrated here), joins the ends of a pair of leading-in wires, which are sealed into a glass bulb. The loop itself is exposed to the action of nitric acid, which dissolves off the silver, leaving a platinum wire of ·00006-in. diameter. This is enclosed in an inner silver shell. The action is that of a bolometer, in which, however, the radiating or absorbing surface is very small as compared with the mass. The heat capacity is proportionately small, and an infinitesimal quantity of heat serves to operate. The glass bulb is exhausted in order further to increase the sensitiveness of the instrument. Shown beside the receiver is a revolving stand containing several of the instruments. The purpose of this is to switch in a fresh receiver immediately should the one in use fail. A high rate of word transmission is claimed also for the Fessenden apparatus, in connection with which the Morse inker has been discarded for a telephone.



From the *Electrician.*

FIG. 4. FESSENDEN'S APPARATUS—WAVE-DETECTOR AND STAND, WITH INSTRUMENTS.

Both the Fessenden and the De Forest systems were tried during the United States naval manœuvres, and answered their trials satisfactorily so far as they went. The distances over which they were tried were not great, but the conditions were fairly stringent. A tug-boat containing the De Forest apparatus was nearly blown out of the water by the *Brooklyn*, and narrowly escaped foundering in a gale; but 95 per cent. of the messages sent were correctly received and were forwarded to headquarters. The installation has been made permanent by the United States Government.

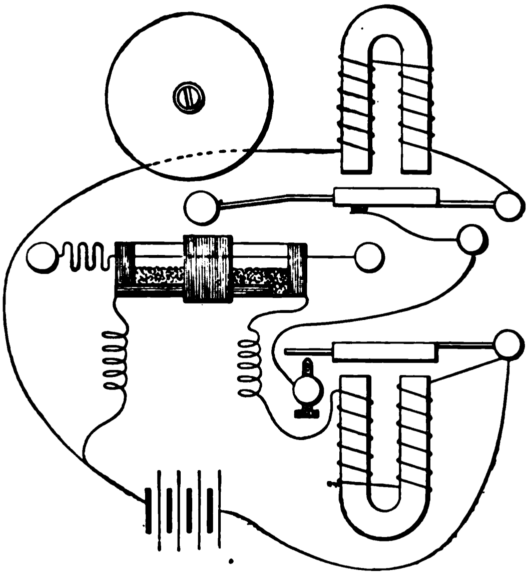
OTHER SYSTEMS.

Space does not permit more than passing mention of other systems which are in use, or which have been proposed. There is one bearing the name of M. Ducretet, who was amongst the earliest French investigators to handle the subject. France also claims the systems of M. Branly, of MM. Rochefort and Tissot, and of Captain Ferrie. Russia has one known by the name of Professor Popoff, the distinguished head of the observatory at Cronstadt. Professor Popoff may claim to have been amongst the earliest experimenters with "wireless" telegraphy anywhere. His researches arose out of the construction of an apparatus for detecting and recording atmospheric electric disturbances, and in 1895 or 1896 he published a communication embodying the use of an elevated or aerial wire, with a coherer and tapper actuating a relay in the same manner as was employed first by Lodge and later by Marconi. In England systems have been devised and tried by Mr. A. C. Brown and Mr. Nevil Maskelyne—with what success is not known, and in Italy there is a system separate from that which is employed in the Navy, bearing the name of M. Guarini, who has made many valuable experiments bearing on the subject. Doubtless others might also be named, for it is a fact that in many private laboratories trials are being made of which little would be known did they not occasionally interfere with one another's results and intercept each other's messages. This, indeed, is likely to be the great difficulty at first with any systems which are taken up commercially. Even the Marconi Company's system, which claims to be so well protected, is by no means perfect yet, if the report be true that all messages sent from Poldhu *viâ* Gibraltar and Spezzia to the *Carlo Alberto* were read by two independent observers, a considerable distance apart, who were able to check their accuracy and also to gauge the rate of signalling attained, and the amount of repetition which was necessary.

PROFESSOR A. POPOFF.

DR. BOSE'S THEORY.

One further name which ought to be mentioned in connection with the development of "wireless" telegraphy is that of Professor Jagadis Chunder Bose, the gifted Indian physicist, whose researches into the action of Hertzian waves and the behaviour of coherers were comparatively early in date and of the highest originality. In a paper read before the Royal Society, April 27th, 1899, he summed up these researches, which were begun in 1895, or earlier, and which included trials of coherers formed by the imperfect contact of almost all the metallic elements. Dr. Bose holds different views from most physicists as to the cause of coherer action. According to him, the alteration in resistance is due to a molecular change, analogous to allotropism, and not to the formation of vapour arcs, or to cohesion in any way. The coherer, according to him, is like a metal in an extremely unstable condition, which only requires a slight strain to throw it off its balance. In most cases the effect of the strain induced by Hertzian oscillations is to lower



From the *Electrician.*

FIG. 5. RELAY AND TAPPER USED BY POPOFF IN 1895.

the resistance; but Dr. Bose's theory presupposes, and in practice he found it to be the case, that coherers can be made in which the opposite is the case, and the resistance, instead of being lowered, is considerably increased. This is especially the case with the alkali metals, potassium, sodium, and lithium, and the fact may be of importance, inasmuch as coherers formed of these metals tend to de-cohere themselves. Theoretically, if the cause of the coherer action is a strain, all coherers should be self-recovering, in accordance with the general torsional rules, and in certain cases, no doubt, they are so. The question of strains, and of the galvanic swing set up by them in almost all kinds of matter, from living muscle to inanimate metals, is one which Dr. Bose has made his special study, and on which he has lately produced some very startling evidence. It was out of his experiments with coherers that these further researches arose, and in dealing with the history of "wireless" telegraphy, in which coherers have played so large a part, it is right that Dr. Bose's work should meet with recognition.

"WIRELESS" TELEGRAPHY OF THE FUTURE.

How far coherers will continue to be used in the future is an open question. The tendency seems to be to eliminate them, at any rate in the filings-tube form, and to substitute other devices for intercepting the transmitted waves. It is rumoured, for instance, that the new Lodge-Muirhead system, which is being kept secret at present, dispenses with coherers altogether. No one can forecast what the "wireless" telegraphy of the future will be, but the chances are that it will not be any of the systems at present in vogue. Judging by historical precedent, the next few years will in all probability witness some great development on quite novel lines, which will render obsolete all the work described in these articles. Even should that happen, the work is worth recording on account of its intrinsic interest, and because the actual accomplishment has been far from contemptible. It is certain that without competition and experiment over long years, the practicable perfect system would never arrive.

NOTES & NEWS.

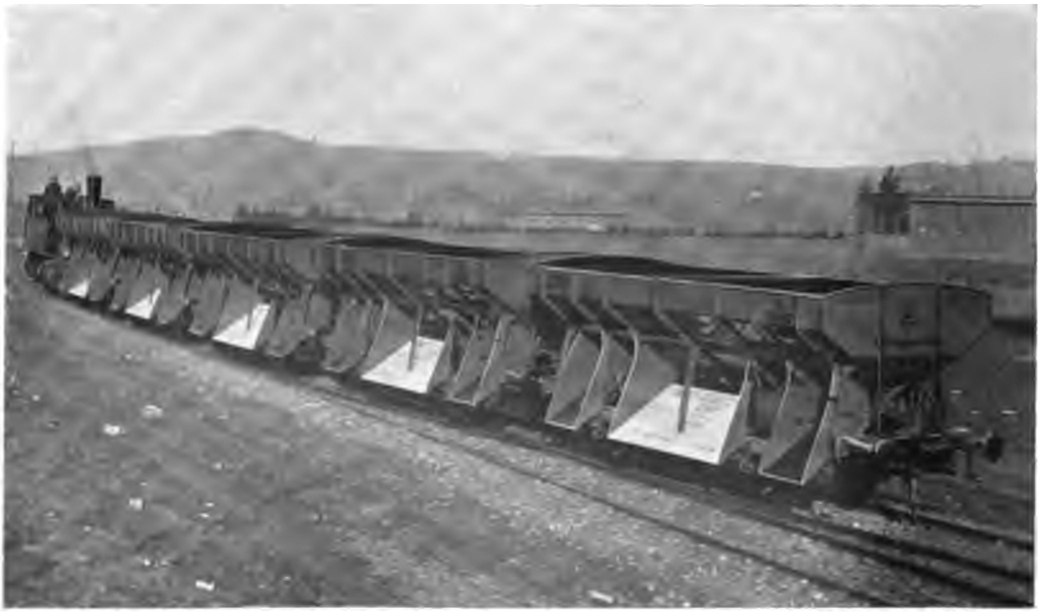
TALBOT SELF-DISCHARGING RAILWAY WAGGON.

The endeavour to supersede hand labour by mechanical means now extends, in Germany, to the loading and unloading of railway waggons, and manufacturers as well as railway companies are beginning to find out the advantage of employing larger waggons that can discharge themselves. The fear that such waggons might not be fully utilised owing to the absence of return load may perhaps be justified to a certain extent in the case of a few unimportant railways with insufficient rolling stock, but certainly not in that of main lines with heavy and regular traffic.

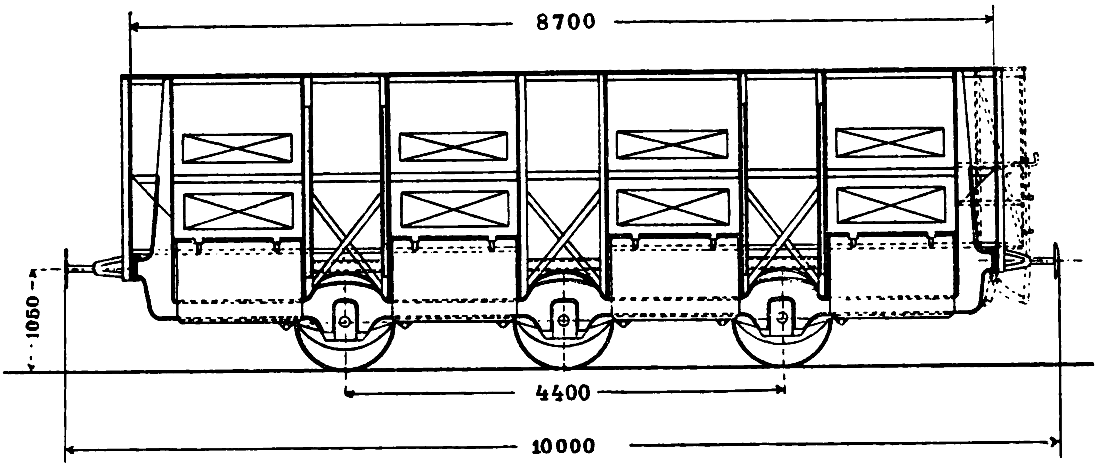
In 1899 the Prussian State Railway carried 248,218,010 tons of goods, including 119,493,973 tons, or 49 per cent., of coal, lignite, and ore, but not including sand, lime, slag, and other such substances of slight value that are also sent off in large quantities. When it is considered that most of the coal and ore consignments were to or from the Ruhr, the Saar, Siegerland, Upper Silesia, or Luxemburg, and that the waggons had, for the most part, to be returned empty, the idea of increasing the capacity and, therefore, better utilising the dead weight, naturally suggests itself.

It is estimated that 3,000,000 tons of coke are now sent yearly by the Westphalian Coal Syndicate to Lothringen and Luxemburg, which corresponds with about 1,000 waggon-loads daily. As these consignments are made by complete trains, the advantage of increasing the size of the waggons, and rendering them self-discharging, is obvious. They can make more frequent journeys, and the number of waggons can be reduced with less encumberment at the stations.

The saving that can be effected at industrial establishments is even greater. For instance, a large steelworks company receives daily 200 10-ton waggon loads of ore



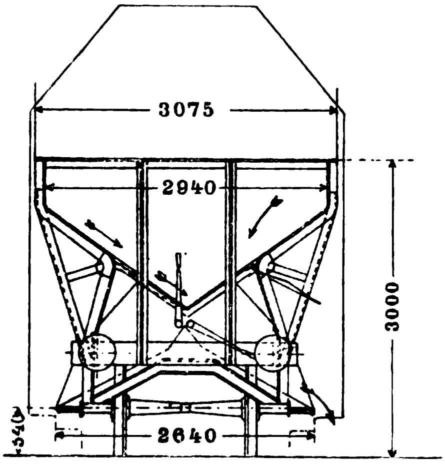
A TRAIN OF TALBOT SELF-DISCHARGING WAGGONS.
Lately supplied to the Prussian State Railway Administration.



SIDE ELEVATION OF 30-TON TALBOT SELF-DISCHARGING WAGGON.

and coal, and the unloading of each waggon by hand costs a shilling, so that the yearly expense on this head is £300,000, which sum might be saved by the use of self-discharging waggons. The cost of such waggons is quickly paid off in the case of large works, where the discharge siding is higher than the general level, or the waggons discharge into a pit, from which coal and ore can be taken up by a bucket chain, as in America. Several German railway administrations are now more and more employing these improved waggons, and it is reasonable to expect that large smelting and manufacturing companies will follow suit.

Messrs. Talbot and Co., of Aix-la-Chapelle, are building a waggon that is intended to combine greater carrying capacity with easy unloading; and they consider that their patent, 20- and 30-ton self-dischargers, made of pressed steel, best solve the problem of economical railway carriage under European conditions, as they permit the load to be discharged automatically on either side at will, or on both sides, clear of the rails, and do not require an elevated track, while the short wheelbase permits of existing turn-tables being retained.



END ELEVATION.

The Talbot self-discharging waggon is claimed to unite in itself all the advantages of tipping waggons, ordinary waggons, discharging at the sides, and hopper waggons discharging at the bottom between the rails. The illustration shows a train of these waggons lately supplied to the Prussian State Railway Administration. Side and end elevations of the 30-ton 6-wheel waggon are also shown, the dimensions being given in millimetres, including length of body, 8,700 millimetres (28 ft. 6 in.); length of under-frame without buffer, 8,700 millimetres (28 ft. 6 in.); extreme height, 3,000 millimetres (9 ft. 10 in.), and breadth over all, 3,075 millimetres (10 ft.).

The waggon sides are inclined to such an angle that the doors formed in them open of themselves, through the pressure of the load directly a bolt is withdrawn; and the body is so much raised above the frame that the load, sliding over guide plates, inclined to an angle of 33 degs., is delivered as far as possible from the rail. For discharging a waggon, including the opening and closing of the doors, it is found that two men require two minutes at the outside, the working of the bolt from the end of the waggon being very simple.

The following example has been adduced to show the great saving, both in first cost and current expense, effected by the 30-ton self-discharger, in conveying 900 tons of iron ore from the mine to the blast-furnace. If this is effected by sixty 15-ton waggons, their first cost will be £6,900, and the yearly expense, including uploading, £1,125, while with the Talbot self-dischargers, the corresponding figures will be £4,700 and £45, showing a saving of £2,200 in first cost, and £1,080 in yearly current expenses.

The Torpedo-Boat Destroyer "Mode."

In November of last year the Swedish Government placed a contract with Messrs. Jarrow and Co., Ltd., for one of their latest type of torpedo-boat destroyers, having a guaranteed speed of 31 knots, and carrying a load of 35 tons. The vessel was finished in August last, its

TORPEDO-BOAT DESTROYER "MODE."
Built for the Royal Swedish Government by Messrs. Yarrow and Co., Ltd.

construction having occupied ten months. The official trial was carried out on August 28th, when a speed of 32·4 knots was obtained during a continuous run of three hours.

There are four Yarrow boilers of the water-tube type, with straight tubes, and two sets of four-cylinder triple-expansion engines. The indicated power of the machinery is about 6,500 h.p. The engines are balanced on the Yarrow, Schlick, and Tweedy system, and during the trial it was found that there was practically no vibration at any speed.

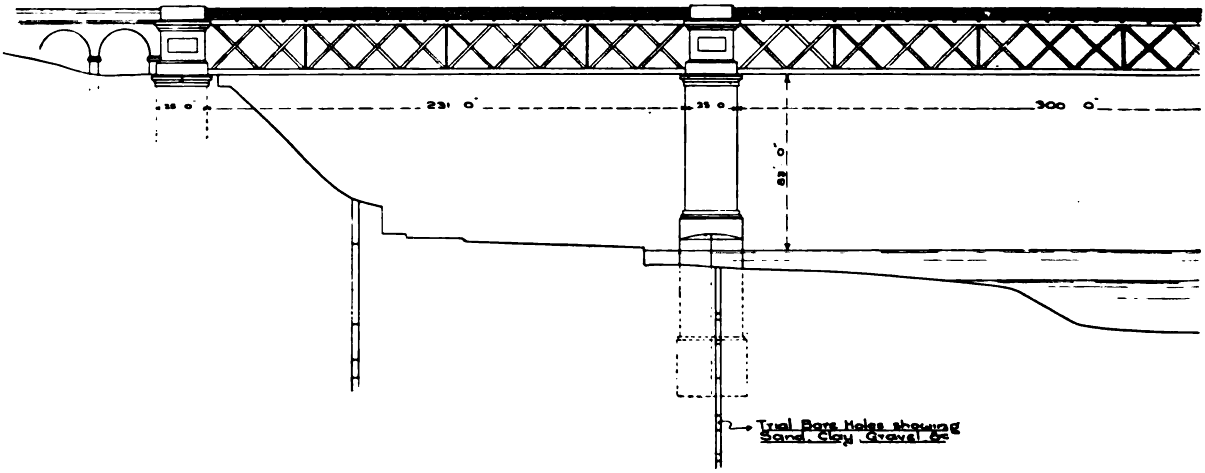
The sub-division of the vessel is very similar to that of other destroyers, but the speed obtained in this instance eclipses any previous performance of vessels built by Messrs. Yarrow and Co., who have constructed for the Japanese Government eight vessels of similar construction.

The Swedish destroyer bears the name of "Mode," which in ancient mythology is the name of the son of Thor, the God of Thunder.

The vessel carries two 18-in. revolving torpedo-tubes aft, suitable for firing at any angle over either side. The gun armament consists of six 57-millimetre quick-firing guns, placed one on the conning tower, one on each bow, one on each side amidships, and one aft. A search-light is placed on the top of the chart house and is in an elevated position, so as to cast the beam of light well over the steersman's head and the forward guns.

The vessel is fitted with heating apparatus throughout, so as to render her habitable during the inclement winter seasons in the Baltic.

She reached Stockholm a few days ago. His Majesty the King of Sweden and Norway had a run in her and expressed himself as highly delighted.



NORTH-EASTERN RAILWAY NEW HIGH LEVEL VIADUCT AT NEWCASTLE.

The New High-Level Bridge at Newcastle-on-Tyne.

The accompanying elevation shows the new high-level bridge over the Tyne at Newcastle, which is being built, to the order of the North-Eastern Railway Company, by the Cleveland Bridge and Engineering Company, Darlington. The structure, which is necessitated by the steadily growing traffic at Newcastle Station, is the largest of the kind erected in Great Britain since the completion of the Forth Bridge, and will involve a cost of something like £470,000. The contract comprises a railway of four lines of road, commencing with a junction with the Newcastle and Carlisle Railway on the north of Forth banks, and terminating with a junction with the main line east of Redheugh Bridge Road, on the Gateshead side, being a length of over half a mile of viaduct. In addition, there is included a connecting loop railway of two lines of road, commencing with a junction at the south end of the bridge, and which, curving eastwards, will join the main line again to the west of Gateshead Station, this second railway forming a viaduct about 800 ft. long.

The commencement of the viaduct on the Newcastle side will be an extension of the arching from Forth Banks up to the Forth Warehouse, the railway being then carried on masonry arches and on steel girder work. The bridge proper will consist of three large spans of steel work, the approach span over the land on the north shore being 231 ft. long in the clear, the two adjoining spans over the river being each 300 ft. in the clear.

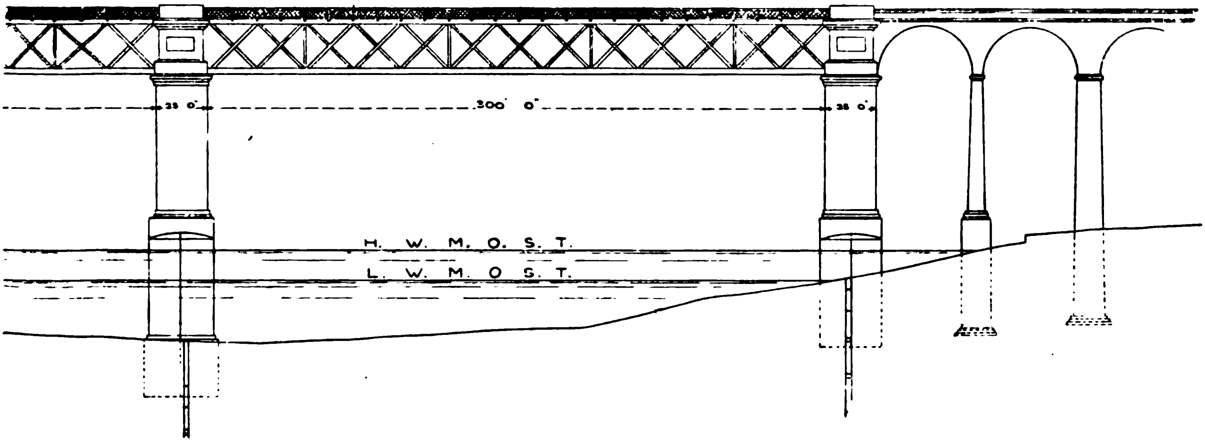
The abutments and piers supporting these spans are of solid grey granite masonry, set in Portland cement. The piers are about 62 ft. wide by 25 ft. in thickness. The foundations of the piers next the river are constructed of watertight cofferdams, built so as to exclude the water while the work proceeds. The foundations for the three main river piers are being made by means of large steel caissons sunk by the pneumatic process to a considerable depth below the bed of the river. The caissons are about 120 ft. in length and 35 ft. in width, the height varying according to the depth of the river.

The height of the underside of the steel girders, forming the superstructure of the bridge proper, will be over 80 ft. above high water. The girders will be of steel and of the usual lattice type, 27 ft. deep; the weight of the 300-ft. span girders being about 300 tons each.

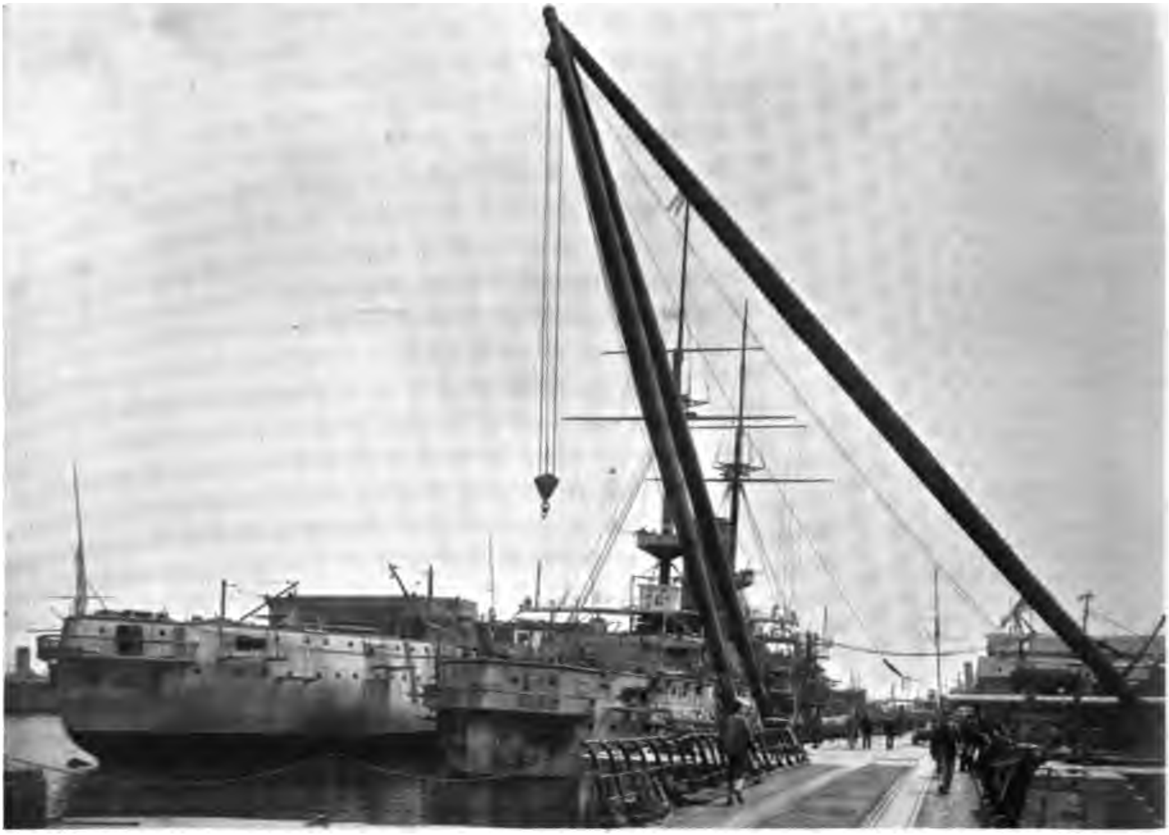
Oil Fuel for Naval Purposes.

The Navy Department at Washington has just issued a report, based upon experiments which have been proceeding for some time to determine the extent to which oil fuel might be used with advantage in the case of warships. The authors of the report show that oil is more expensive than coal in the proportion of 14 to 10, and that it is more dangerous to handle. At the same time, the many advantages of oil are not denied, one of them being that steam can be generated more quickly by its use than with coal Lieut. Winchell, of the United States Navy, who was deputed to report on the voyage of the steamship *Mariposa*, which steamed 8,000 miles exclusively on oil, speaks almost entirely in its favour. In addition to the greater rapidity of steam generation, he claims for oil that it leaves no ash to be dealt with, that fewer firemen are needed, that, comparatively, there is no smoke, that greater heat is produced in a given space, and that oil can be more compactly stowed.

An "International Engineering, Machinery, Hardware, and Allied Trades Exhibition," will be held at the Crystal Palace from March 2nd to May 31st, 1903, under the distinguished patronage of Lord Kelvin, the Earl of Stanhope, Lord Strathcona, and many other leading men connected with industries coming within its scope. A number of influential engineering firms have arranged to exhibit, and the promoters confidently hope that the exhibition will be a decided success.



ELEVATION OF STEEL SPANS OVER THE RIVER TYNE.



THE GREAT SHEERS AT CHATHAM DOCKYARD.

NAVAL NOTES.

MONTHLY NOTES ON NAVAL PROGRESS IN CONSTRUCTION AND ARMAMENT.

BY

N. I. D.

DURING the last two months nearly all the great powers have been carrying out manœuvres with their principal fleets and squadrons. This system of instruction, which has become an established custom of recent years, affords not only an exercise for the officers of the respective fleets and the men under them, but is also a test of the powers of the ships engaged. In this connection it is noteworthy that we hear much less now than we did in previous years of ships breaking down one after the other and having to return to the dockyards for refit. And this may be said to be true not only in the case of our own vessels but in those also of foreign powers. The explanation is not far to seek. There can be no doubt that a vessel which has been running some little time is far less likely to develop defects than one which has been but a short time under the pennant. Even in the case of specially commissioned ships the lesson has gone home and the reserves in the dockyards are maintained in a condition far more ready for use than was the case before the Naval manœuvres were instituted.

It is noteworthy as regards the scheme of operations which the several powers have chosen for their exercises, that these differ considerably in scope and object. In the United States the manœuvres were divided into two parts, the first section of which was concerned with a notion very prevalent in the American coast ports during the late war. It was assumed that some European admiral was attempting to secure a base for operations on the American littoral between Chatham, Mass., and Portland, Me. The enemy, in fact, was supposed to be endeavouring to find a Guantanamo on the United States coast, regardless of the circumstance that the defender had still a fleet "in being." The outcome was a meeting between the two forces, in which the enemy being the weaker went to the wall. The second section of the manœuvres was of a similar nature, inasmuch as it included combined operations with the Army upon a scheme of coast attack and defence, the establishment of a temporary base being again the object of the enemy. The "alarums and excursions" which ensued are described as picturesque and imposing, and they may, indeed, have served as a test of the army system of coast defence. But none knows better than the United States naval authorities that battleships are not intended for the purpose of attacking forts, and their ulterior object in drawing up their schemes seems more likely to have been to attract and rivet public attention upon the Navy, and to keep the needs of the nation in this connection well in the public eye.

In Germany, as might have been expected, the operations have a very practical character, everything which might be styled "showy" being eliminated. Such scheme as there was may be said to have been tactical rather than strategical, portions of the period of operations being devoted to target practice, to scouting exercises, and to night attacks. The operations were conducted partly in the Baltic and partly in the North Sea, and much experience would therefore be gained by the officers in navigating the difficult waters in that region. The exercises in scouting are reported to have been very thorough, as were also the tests applied to the mobilising organisation of the torpedo flotillas and the ships in reserve. Students of naval warfare will unquestionably find much of interest and instruction in an attentive study of the useful and practical exercises of the German Squadron.

The French manœuvres have been also particularly instructive. They appear to have demonstrated the value of improvements recently introduced in connection with mobilisation and the very satisfactory condition into which the effective material of the fleet has been brought. Although a very large number of vessels of varying types and classes were engaged in the operations, no serious defects are reported to have been developed. The strategical schemes were mainly concerned with the possibilities of adequately observing the movements of hostile squadrons through the Mediterranean by the Straits of Gibraltar and the passage through the south of Sardinia. By means of lines of cruisers and "wireless" telegraphy it was found that prompt intelligence could be obtained and conveyed to the bases of such movements, results not without significance to ourselves. The tactical exercises took the form of experimental trials with various fighting formations of the forces engaged. It is now a fact well recognised by naval officers that, with modern material of war, the methods employed by our ancestors of winning naval battles need considerable modification. The principle—that of throwing an overwhelming force upon some portion of the enemy's line, and thus destroying it in detail—is the same. At the Nile and at Trafalgar, Nelson accomplished this result by tactical movements, which enabled him to bring the greater portion of his ships to bear upon a smaller portion of the enemy's vessels, their comrades being unable to come to their assistance in time, in one case, because they were at anchor, and, in the other, because the wind would not enable them to do so. To-day ships are independent of the wind and, moreover, the threat of the torpedo will prevent, and the long range of the guns remove, the necessity for close action. But the object may be attained if an admiral can succeed in bringing a preponderating fire from the guns of his ships upon a single ship or a section of the force of his adversary. In France, therefore, and in this country tactical exercises have recently taken the shape of attempts to prove the merits or demerits of various fighting formations, with a view of attaining this result. It is obvious that the method in which Nelson and Collingwood took their ships into action at Trafalgar would now result in the foremost ships receiving the concentrated fire of the enemy, and being knocked to pieces before their friends got into action. It is unnecessary here to enter at length into the subject, which may be dealt with in a future article; but it may be pointed out that it has a direct bearing upon the design of ships of war, particularly in regard to the manner of distributing their guns. The French are said to have been taught some important lessons by the trials they have carried out, and doubtless the exercises of a similar nature by our ships in the Channel and the Mediterranean have been equally productive of valuable results.

A BATTLESHIP RECEIVING HER SKIN PLATING.
Building the *Venerable* at Chatham.

GREAT BRITAIN.

In "Naval Notes" for September reference was made to the *Duncan* class of battleships, of the programmes of 1898-1900. Three of these ships have completed their trials—the *Russell*, *Exmouth*, and *Montagu*, which were built respectively at Palmer's Yard, Jarrow, at Laird's Yard, Birkenhead, and at Devonport Dockyard. All three of the remaining ships are now at Chatham, the *Albemarle* having been built there, and the *Duncan* and *Cornwallis* delivered from the Thames Shipbuilding Yard at Blackwall. It is anticipated that all six vessels will be ready for commission before next summer.

At the recent trials of the armoured cruisers of the *Drake* class, the following results with full power were obtained: *Good Hope*, 23·05 knots, with 31,071 i.h.p.; *Leviathan*, 23·23 knots, with 31,303 i.h.p.; *Drake*, 23·05 knots, with 30·849 i.h.p.; and *King Alfred*, 23·46 knots, with 30,893 i.h.p. In September the *Drake*, fitted with experimental propellers, underwent further trials. Three series of runs were made on the measured mile in Stokes Bay, and four series of runs over the deep sea course in Chesil Reach. Each series comprised four runs, two with and two against the tide. The following figures indicate the various speeds:—9·52 knots, with 1,685 i.h.p.; 13·06 knots, with 4,014 i.h.p.; 15·41 knots, with 6,520 i.h.p.; 17·93 knots, with 9,872 i.h.p.; 20·03 knots, with 14,801 i.h.p.; 22·16 knots, with 22,534 i.h.p.; 24·11 knots, with 31,409 i.h.p. These results are a considerable improvement upon the former trial, and will probably lead to an alteration in the propellers of other ships. The *Good Hope*, of this class, has been commissioned as the flag ship of Rear-Admiral W.

H. Fawkes in the cruiser squadron, which will also include the *King Alfred*, the vessels relieved being the *St. George* and the *Juno*.

Of the "County" class of ships, three more have now been launched—the *Donegal*, launched from the Fairfield Shipbuilding Company's Yard on September 4th; the *Berwick*, launched from Messrs. Beardmore and Co.'s Yard on September 20th; and the *Cornwall*, launched at Pembroke on October 29th. Thus the *Suffolk* and *Cumberland* alone remain to complete the list of vessels of this class.

Reference has already been made in these notes to the programme of Naval Construction of 1901-02, which consisted of three battleships, six armoured cruisers, two third class cruisers, ten torpedo-boat destroyers, five torpedo-boats, two sloops, and five submarine boats. The battleships were named the *King Edward VII.*, now building at Devonport, the *Dominion*, to be built at the yard of Messrs. Vickers, Sons, and Maxim, and the *Commonwealth*, which is being built by the Fairfield Company on the Clyde.

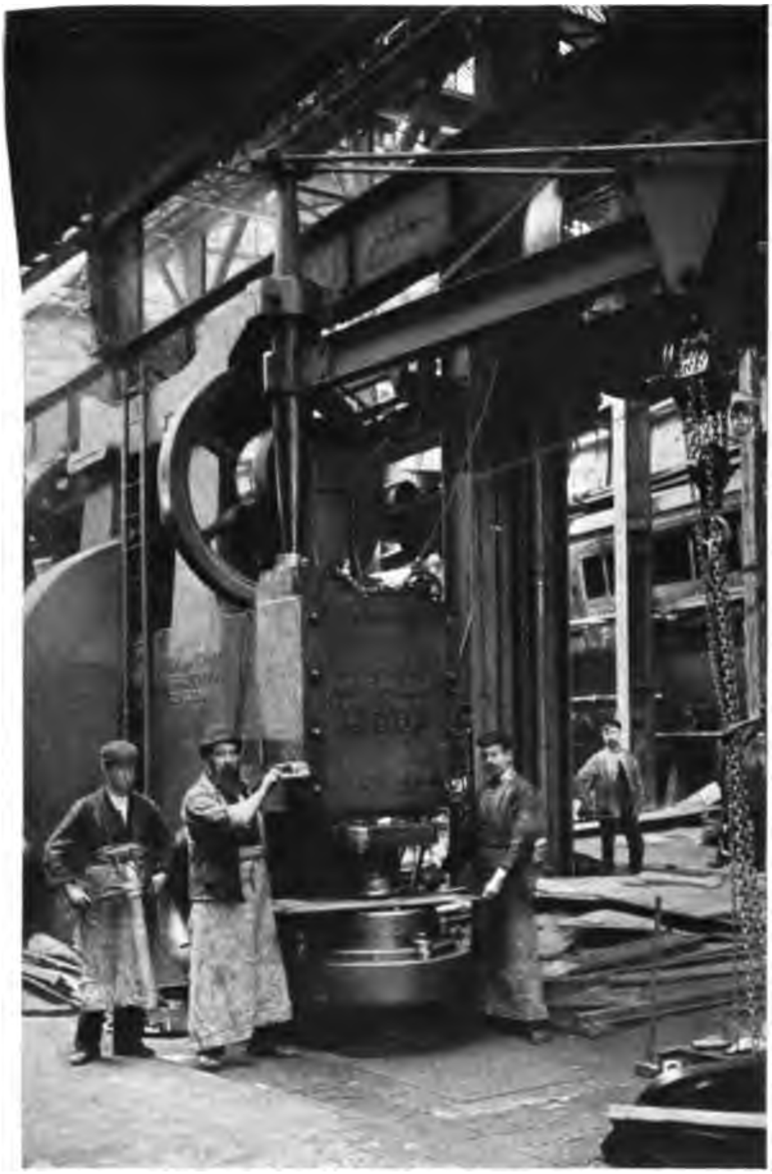
The six armoured cruisers in the programme are those already referred to as of the *Devonshire* class. The contracts for these vessels have now been given out. They will carry a rather heavier armament than the previous ships of the *County* type, and will consequently be of heavier displacement. A novel feature is a result of the recommendation of the Boiler Committee, by which in these ships the boilers are partly of the water-tube and partly of the cylindrical type. The *Devonshire*, building in Chatham Dockyard, and the *Carnarvon*, building by Messrs. Beardmore and Co., will each of them have a combination of four-fifths Niclausse and one-fifth cylindrical. The *Hampshire*, building by the Elswick firm, and the *Antrim*, building by Messrs. J. Brown and Company, will have a combination of four-fifths Yarrow, and one-fifth cylindrical boilers. The *Roxburgh*, at the yard of the London and Glasgow Shipbuilding Company, will be provided with a combination of four-fifths Dürr and one-fifth cylindrical, while the *Argyll*, to be built by the Greenock Foundry Company, will have a combination of four-fifths Babcock and Wilcox, and one-fifth cylindrical.

The two third-class cruisers of this programme are to be named *Amethyst* and *Topaze*, and the ten torpedo-boat destroyers, particulars as to the building of which were given last month, are the *Eden*, *Derwent*, *Ettrick*, *Exe*, *Foyle*, *Itchen*, *Ribble*, *Teviot*, *Usk*, and *Erne*. The torpedo-boats numbered 109 to 113 inclusive are building at Messrs. Thornycroft's yard, Chiswick. Of the submarine boats all are finished, and three have been delivered at Portsmouth. The programme for 1902-03, comprised two battleships, two armoured cruisers, two third-class cruisers, four scouts, nine destroyers, four torpedo-boats, and four submarines. The battleships of this programme will be of the same type as the *King Edward VII.*, described above. One, to be named the *New Zealand*, will be built at Portsmouth on the slip from which the *Suffolk* is to be launched; the second, to be named the *Hindustan*, will be built at the yard of Messrs. John Brown and Co.

The cruisers and scouts have not yet been contracted for, but the nine torpedo-boat destroyers are to be built—the *Cherwell* and *Dee*, by Messrs. Palmer; the *Kennet*, and *Jed*, by Messrs. Thornycroft; the *Welland*, by Messrs. Yarrow, the *Waveney*, by Messrs. Hawthorn, Leslie and Co.; the *Arun* and *Blackwater*, by Messrs. Laird; and the *Velox*, by the Parsons Turbine Company. The four torpedo-boats are to be built by Messrs. J. S. White and Sons, of Cowes.

FRANCE.

There is nothing of importance to add this month to our notes on battleships, but another armoured cruiser has been placed in the water. This vessel is of the *Desaix* class, of 7,700 tons displacement. The armament consists of eight 6·4-in. guns in turrets, one forward, one aft, and one on either beam, four 3·9-in., ten 1·85-in., and four 1.45-in. guns. She also carries two 17·7-in. torpedo tubes. Her length is 420·5 ft. between the perpendiculars; beam 58·7 ft.; draught, 23 ft. The engines of, 17,400 h.p., supplied with twenty Niclausse boilers, are to give a speed of 21 knots. The normal coal supply is 880 tons, which can be increased to 1,200 tons. Protection is given by an armoured belt 4·33 in thick at the water line, and an armoured deck below this, while the space behind the armoured belt is filled with a water-tight cellular structure. She is sheathed and coppered for cruising on foreign stations, and her complement is 578 officers and men. The *Dupleix*, the first of the class to take the water, was launched in 1900 at



A MANHOLE PLATE-PUNCHING MACHINE IN CHATHAM DOCKYARD.
Will punch a 23-in. hole.

Rochefort, and has been under trial in active service. The *Desaix* was launched at St. Nazaire on March 21st, 1901; and the *Kléber* at Bordeaux on September 20th. The latter will shortly undergo her trials.

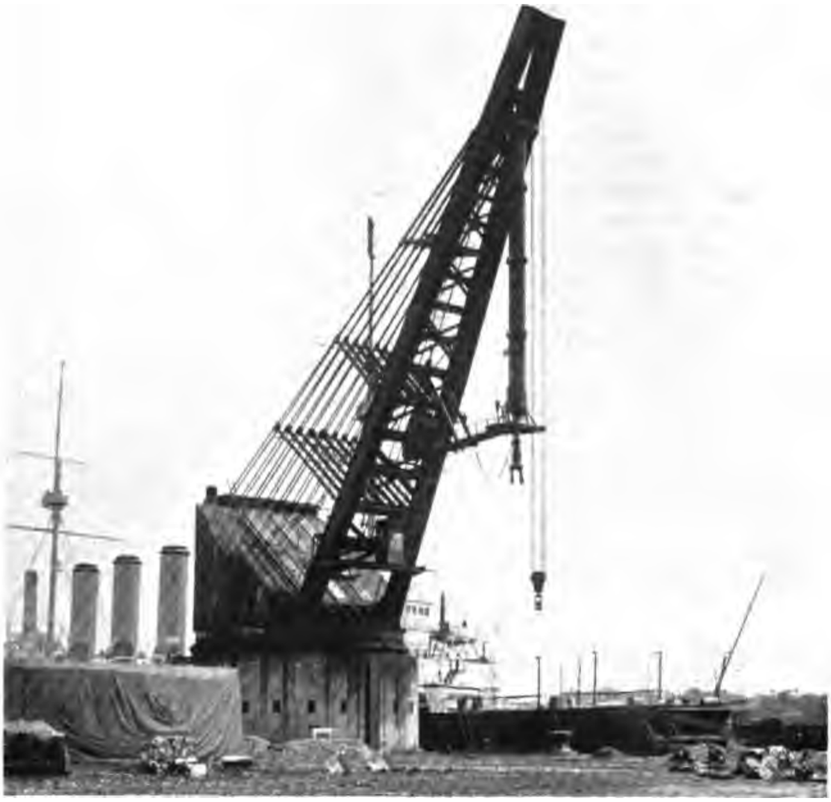
Of the three ships of a rather larger type, mention has already been made of the *Montcalm*, of 9,517 tons displacement. A second ship of this class, the *Amiral de Gueydon*, is so far advanced at L'Orient that she has made her preliminary trials. This vessel is fitted with twenty-eight Niclausse water-tube boilers, in four groups, and it is intended that her engines shall develop 19,500 i.h.p., giving a speed of 21 knots. The third vessel, the *Dupetit-Thouars*, was launched at Toulon on July 5th, 1901.

The first-class protected cruiser *Chateaurenault* has been passed into active service. She was launched more than four years ago, and has been making her trials ever since. It was intended that she should have the speed of 24 knots, and this she actually attained, her engines developing 24,300 i.h.p. Her sister ship, the *Guichen*, it will be remembered, failed to attain this speed, and it is unlikely that the *Chateaurenault* will repeat it on active service. These two so-called commerce destroyers are only protected by an armoured deck, and they carry two 6·4-in. and six 5·5-in. quick-firing guns, on a displacement of 8,018 tons.

GERMANY.

It is officially announced that the new battleships of the *Wittelsbach* type are to be ready for their trials—the *Wittelsbach* and *Wettin* immediately, the *Zahringen* towards the end of the year, the *Mechlinburg* next spring, and the *Schwaben* towards the end of 1903.

The armoured cruiser *Prinz Heinrich*, of 8,870 tons displacement, has successfully completed her trials, developing 15,703 i.h.p., which gave her a mean speed of 20 knots. She has also made a twenty-four hours' coal consumption trial, with the following results: The air pressure was ·39 in., the i.h.p. 10,355, and the coal

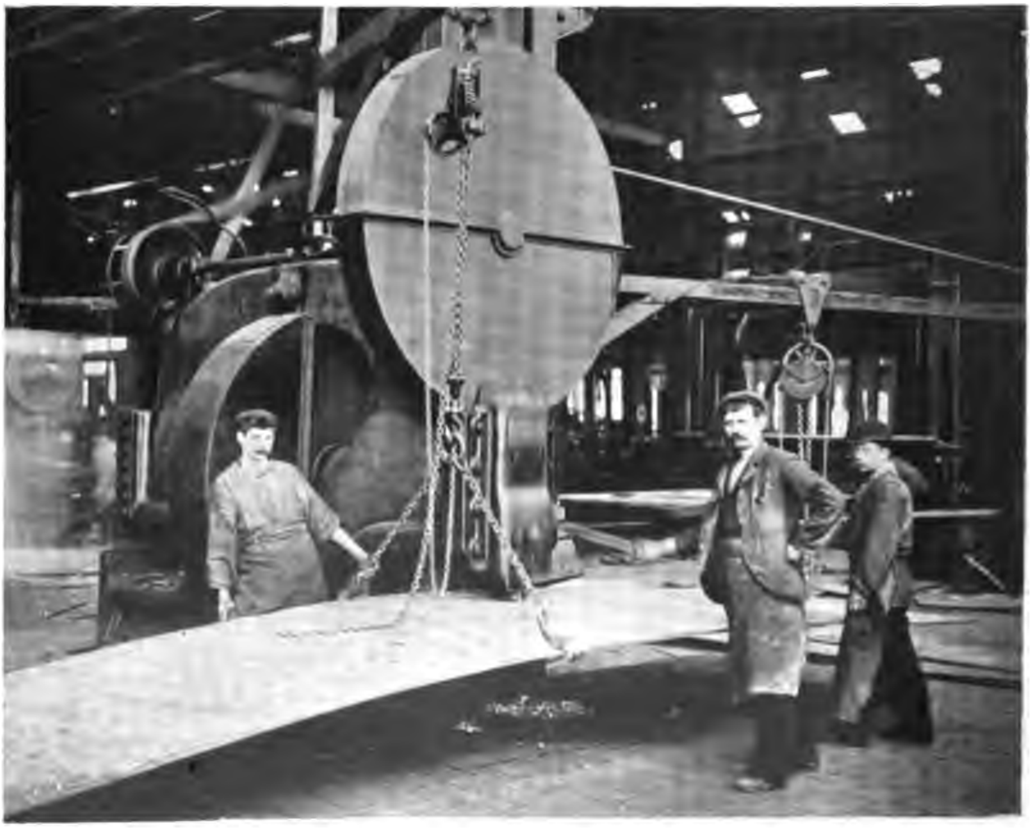


THE 150-TON CRANE IN CHATHAM DOCKYARD.
The largest in the Yard.

consumption 1·193 lbs. per unit of power per hour. This vessel has three screws, driven by three sets of separately mounted four-cylinder triple-expansion engines. She has a coal stowage of 950 tons, at ordinary draught. The armament consists of two 9·5-in. guns, each in a revolving turret, one forward and one aft, and having an arc of fire of 270 deg.; ten 6-in. guns, six in a casemate, three on each side, mounted in such a manner that two can fire right ahead and two right astern; the others are mounted singly in revolving turrets above the casemate, and of these also two can fire right ahead and two right astern. The remainder of the armament consists of ten 3·5-in. quick-firing and ten 1·5-in. machine guns, placed on the upper deck and superstructure, and in the fighting tops. The torpedo armament consists of four 18-in. tubes. Armour protection is given by a water-line belt extending the whole length of the ship, and being 4 in. thick at the water line. The turrets have an armoured thickness of 6 in., and the casemates and smaller turrets of 4 in. The ammunition shafts are also armoured, and the protected deck is of 2 in. thickness, tapering to 1·5 in. The complement consists of 504 officers and men. This vessel took part in the naval manœuvres this year.

The *Prinz Friedeiich Karl*, the launch of which ship was referred to in the August number, is somewhat similar to the *Prinz Heinrich*, but differs in her armament and is of somewhat heavier tonnage, the displacement being 9,050. Her length is 393·7 ft.; beam, 64·3 ft.; and draught, 20·3 ft. The armament will consist of four 8·27-in. Krupp guns, placed in pairs in two turrets, one of these being forward, on the deck above the casemate, the other aft, on the casemate deck, but not within it. In the casemate itself are placed six 5·9-in. guns, three aside, the foremost pair being able to fire directly ahead, and the after pair directly to stern. Above the casemate are four more 5·9-in. guns, making ten in all. These four guns are each in a single turret, one at each corner, and having the same arc of fire as the guns at the corners of the casemate below. As in the *Prinz Heinrich,* the upper works are thrown inward, so as to permit of these guns having bow and stern fire. There are also twelve 3·5-in. quick-firing and four 1·5-in. machine guns, mounted on the decks, bridges and tops. There are to be five submerged 18-in. torpedo-tubes, and one armoured tube above water at the stern. Like the *Prinz Heinrich,* the *Prinz Friederich Karl* is protected by a complete belt of armour. In the latter ship, this belt is 7·5 ft. wide and 3·9 in. thick on the beam, and 3·2 in. thick at the bow and stern. Above this belt is a shorter one, 165 ft. long, of 3·9 in. armour, and this runs as high as the floor of the casemate which affords protection to the secondary battery. The armoured deck running behind the belt and sloping to meet its lower edge is 2·8 in. thick on the slopes, and 1·6 in. on the flat. The upper deck outside the casemate has 1·2 in. of armour, and the deck over the casemate 1·4 in. The turrets for the heavy guns are protected by 5·9-in. armour; the turrets for the smaller guns and the casemate with 3·9-in. armour. The loading tubes and ammunition hoists are also all slightly more than 3 in. thick. In this cruiser steam is supplied by fourteen water-tube boilers, the engines are to develop 16,000 i.h.p., and the anticipated speed is 21 knots.

Two river gunboats of 11·5 knots speed have just been completed at Hamburg for service in Africa, and a third of somewhat different dimensions, and to have a speed of 13 knots, is to be built in the Schichau Yard at Elbing for service in China. We have already referred to a division of six destroyers to be constructed at Elbing, and append details of six new boats



PUNCHING A SHIP'S PLATE.

building at the Germania Yard. These will be 215 ft. 10·5 in. in length over all, 22 ft. beam, 8 ft. 10 in. draught, and of 350 tons displacement. The armament will consist of three guns and three torpedo-tubes. These boats are intended to maintain a speed of 26 knots with engines working, and 5,000 i.h.p. They are twin screwed, have two funnels, with the signal masts abaft both of them, and the bridge forward. At full draught they carry 100 tons of coal, giving a radius of action of 2,000 miles at 12 knots, and the complement consists of 49 officers and men.

ITALY.

The *Italia Militare e Marina*, in a recent article on the torpedo-boat destroyers of the Italian Navy, stated that out of eight destroyers of the first class four have seen fourteen years' service, and one thirteen. Out of ninety-four second class destroyers, four only have a displacement of 110 tons, all the others being of 70 tons, while not one can carry more than 17 tons of coal. Two are seven years old, six are eight years, while eleven date from 1893. Twenty more have been on service since 1892, one since 1890, forty-five since 1888, and six since 1887. The remainder date from 1886. Of all these vessels only two can be deemed serviceable, and those are the seven-year-old ones. The third-class destroyers, of which there are thirty-eight, date back as far as 1882, and none are of later date than 1888.

RUSSIA.

Since 1899 Russia has, in a measure, reconstructed that portion of the fleet we term protected cruisers. The *Diana* class, of 6,630 tons, consists of three ships, her sisters being the *Pallada* and the *Aurora*. These vessels have a speed on trial of slightly over 19 knots. The next class consists of one vessel only. This is the *Vitiaz*, which was laid down at Gelerny Island, St. Petersburg, on November 3rd, 1900, but owing to a fire in June, 1901, she was virtually destroyed, and her construction had to be recommenced. Her displacement is 6,375 tons. The engines are of 19,500 i.h.p., supplied with steam by sixteen Normand boilers, and the estimated speed is 23 knots. In the next class are the *Bogatyr* and *Askold*, mentioned last month. They are of 6,500 tons displacement, and similar dimensions to the *Varyag*, which was built in Philadelphia. Two similar vessels are said to be building at Wyandua and Libau respectively, while two others are reported to be about to be put in hand at the Nevski Yard at St. Petersburg.

Of smaller protected cruisers eight are reported to be in hand. These are the *Alma*, *Izumrud*, *Jemtchug*, and *Oleg*, building at St. Petersburg; the *Boyarin*, launched at Copenhagen on June 8th, 1901; the *Novick*, built at Dantzic, and reported to have attained a speed of 26 knots; the *Kalgoula*, said to have been laid down at Nicolaeff, and an unnamed ship, ordered from Messrs. Schichau, at Elbing. Another class, said to be a modified edition of the *Bogatyr* type, consists of the *Kagull*, building at Nicolaeff, and the *Otchakoff* at Sebastapol. These vessels are reported to have a displacement of 6,250 tons, 19,500 i.h.p., and an intended speed of 23 knots. In regard to nearly all these cruisers some uncertainty exists.

SWEDEN.

The *Acram*, coast defence vessel, mentioned in the August number, is reported to have completed her trials. This vessel is of 3,700 tons displacement, 6,500 i.h.p., and steam is supplied by eight Yarrow water-tube boilers. The mean speed exceeded that anticipated by the contract by six-tenths of a knot, and the horse-power obtained also exceeded that which was anticipated, being 7,500, giving a speed of 17·26 knots. The coal consumption worked out at 1·78 tons per unit of power per hour. Messrs. Yarrow and Co. have also completed for the Swedish Government a torpedo-boat destroyer ordered in November last year.

MEXICO.

Two gunboats for Mexico were launched at Elizabeth Port, N.J., on September 13th, and named the *Tampico* and *El Cruz*. They are steel vessels, 201 ft. 6 in. long, 32 ft. 10 in. beam, 10 ft. draught, 980 tons displacement, and 16 knots speed. The armament consists of four 4-in., and four 6-pounder guns and one torpedo-tube. Steam is supplied by Moshe water-tube boilers, and the coal capacity and ordinary draught is 170 tons. Fore and aft sail power for auxiliary purposes is given on two pole masts. The only protection is that afforded by the coal bunkers.

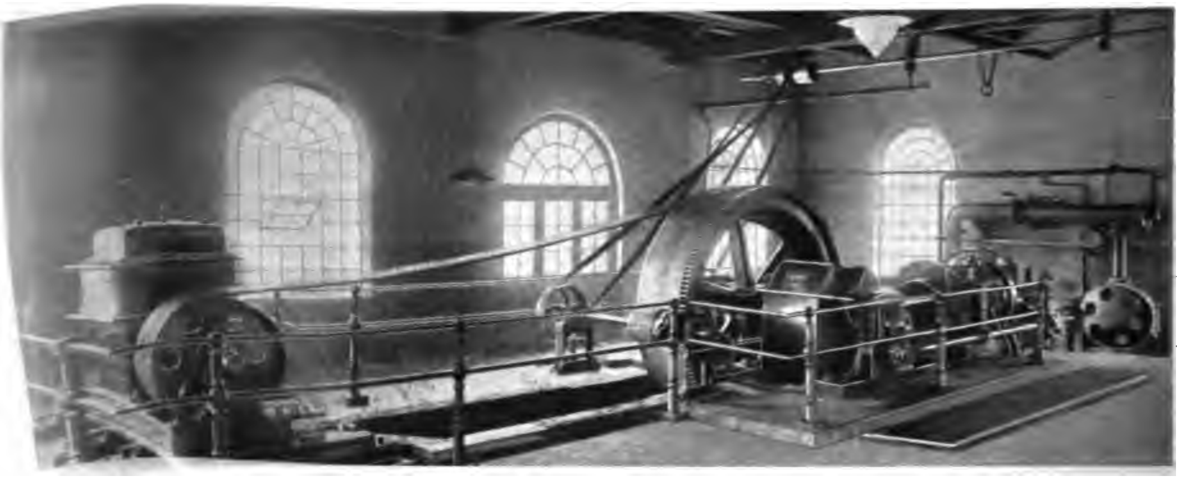


FIG. I. THE ELECTRIC LIGHT AND POWER GENERATING STATION. THWAITE-GARDNER BLAST-FURNACE POWER SYSTEM. SHEEPBRIDGE COAL AND IRON COMPANY, LTD.

IRON AND STEEL MANUFACTURE.

CHARGING OF MINERAL AND FURNACE EQUIPMENT.

BY

B. H. THWAITE, C.E.

In the three preceding articles the author dealt with the choice of site, the selection of ores, and the most economic methods of transportation from the mine to the mouth of the furnace.—ED.

IV.

SOME FURTHER AND CASUAL NOTES ON THE CHARACTER OF STOCKYARD ARRANGEMENTS.

IN the present article a further reference may with advantage be made to the stockyard arrangements. If satisfactory these should obviously secure the command of an adequate and continuous supply of minerals for the furnace, and they should also be sufficiently compact to require the least possible necessity for transport. It is, of course, impossible to formulate a scheme that will uniformly satisfy all conditions, as so much depends upon the topographic characteristics of the furnace site, and the distance from the main railway. The schemes will require to be further modified, if blast furnaces are directly associated with open hearth steel furnaces.

An entirely satisfactory stockyard and house arrangement should include the adequate provision of covered mineral bins, with associated arrangements for securing the removal of some part of the sensible moisture from the minerals before they are charged into the furnace.

Any blast-furnace arrangement designed to secure the maximum of efficiency will include the provision of arrangements to preserve the coke and mineral from the effect of wet weather, as

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The previous articles were: The choice of a site—The trend of modern progress—The choice of ores (four maps and two diagrams) July; The transportation of the mineral from the mine to furnace stockyard (fourteen illustrations) August; Transportation of mineral from furnace stockyard to mouth of furnace (thirteen illustrations September.

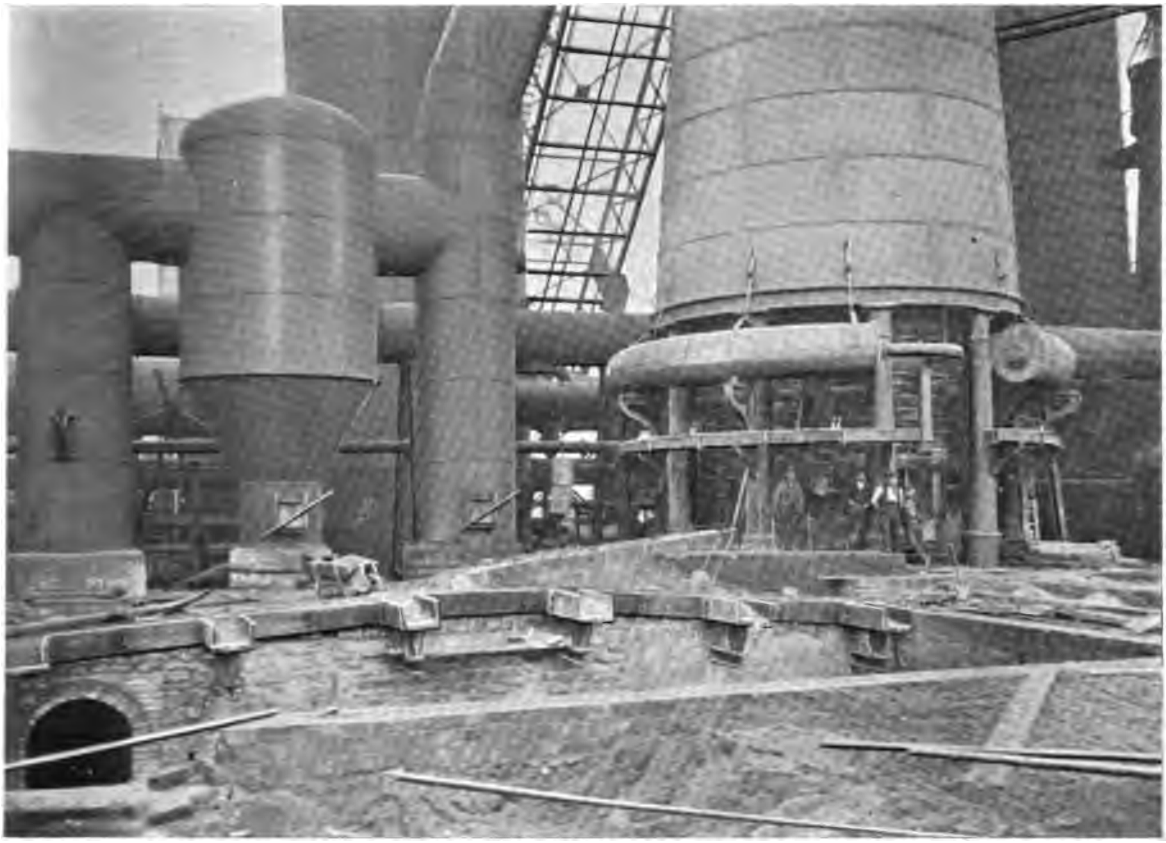

FIG. 2. THE NEW ANGLO-AMERICAN FURNACE OF THE SHEEPBRIDGE COAL AND IRON COMPANY, LTD.
Showing the Dust-Catchers, and in the rear the Furnace Inclined Hoist.

it is well known that coke will absorb or retain a considerable percentage of its own weight of water. It may, however, be assumed that the moisture included in ordinary coke and limestone will absorb theoretically some 2 per cent. of the thermal assets contributed by the coke, in effecting merely the evaporation of the sensible moisture carried into the furnace by the minerals. Very probably in the process of practically effecting the evaporative operation, at least 4 per cent. of the thermal assets are absorbed; so that in a furnace requiring 500 tons of coke per diem, 20 tons of coke is absorbed in evaporating the sensible moisture; and a simple calculation will show that the capitalised value of this wasted thermal energy would economically justify the provision of roofing covers for the coke and ore stocks.

The American system of employing double stock bins is excellent; a section of such a stock bin is shown on p. 282.* In one American example, and typical of the best practice, 130 double deck stocking bins are provided. The upper bins provide store rooms for the coke and the limestone, and the lower ones are allocated for the reception and storage of the iron ore. Each of the bins has a sectional area in plan of 256 square feet, inclosed in sides 16 ft. by 16 ft. The floors of the bins slope at

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* The stockyard arrangements of the Sharon Iron Co., Ltd., U.S.A., consist of four railway sidings traversing the stockyard, two of which are elevated, and run alongside the open hearth steel furnace charging platform. At the end of the stockhouse is located the mixing house, equipped with ore-breakers or pulverising machinery. Alongside the stockhouse there is a machine shop constructed of steel and brick, 114 ft. wide by 132 ft. long. The machine shop is commanded by a 20-ton electric crane, and is equipped with a full complement of modern repairing and erecting tools, such as shapers, boring mills, planers, etc. The blacksmith's shop is a capacious structure, 190 ft. long by 75 ft. in width, and has associated with it a carpenter's shop equipped with modern woodworking tools.

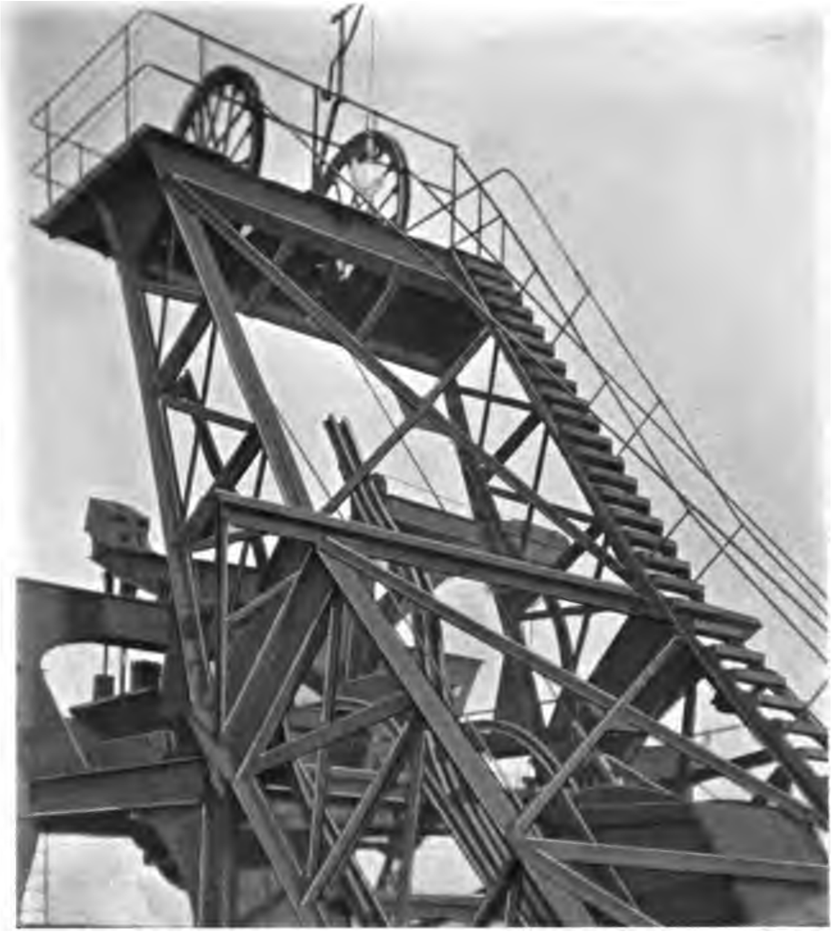

FIG. 3. THE HOIST AND THE CHARGING GEAR OF THE NEW ANGLO-AMERICAN FURNACE OF THE SHEEPBRIDGE COAL AND IRON COMPANY, LTD.

an angle of 45 deg., and are formed of maple planks laid on a backing of 4 in. of oak.[*] The mineral freight cars run directly over the two decker or double stage bins, and discharge their contents directly into them. The discharge of the minerals is effected by guillotine or rotating discharge doors, which allow the minerals to fall into a transport car or into a conveyor band—a method of electric transport that has already been described in these columns.[†]

For covering these stock bins, either a roof can be supplied or the hatchway openings can have sliding doors to prevent atmospheric moisture or rain from entering the bins. The author strongly urges the economic importance of maintaining the coke and ore in as dry a condition as possible prior to their removal to the furnace.

ANGLO-AMERICAN EXAMPLES OF MINERAL ELEVATION AND FURNACE CHARGING.

Although the majority of British blast furnaces are almost archaic compared with the modern American furnaces, still there are signs of a great change. The rigid conservatism that has prompted the British manufacturer to cling to obsolete plant, and uneconomical and irrational processes, is at last breaking down, and it is cheering to know that the breach thus made, is becoming wider day by day.

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[*] In the construction of mineral stock bins it is found that it is more economical to employ heavy oak timber than to use steel. The bins are generally equipped with double discharge doors.

[†] The weigh-bridge electric ore transporting cars, after receiving their mineral contents from the stock bins, move around a loop, the arrangement of transport being such that in one direction the cars are receiving their charge, which they deliver to the furnace elevator or hoisting skips, returning in sequence from an opposite direction to receive additional mineral from the stock bins. The coke and ore transporter cars are constructed of steel, having square cross sections, bevelled bottoms and sides, and a holding capacity of 75 cubic feet.

Some of the more progressive and receptive of our manufacturers, have weighed and measured by their own personal contact and examination the pros and cons of the modern American practice, and they admit that the changes from British practice have been justified by results, and the Americanisation of British furnaces has commenced.

The danger is that British manufacturers will only make tentative or incomplete changes, and we know that a timid application of a new system often proves a comparative failure, where a more complete process of reform would have proved an encouraging success. Of course, there are circumstances that absolutely compel the employment of modifications only, but whenever possible the full programme of all the essentials of proved importance should be embodied in the design or scheme of industrial reform.

A British firm which has adopted American methods of hoisting and charging minerals is the Sheepbridge Coal and Iron Company, Ltd. Mr. Herbert Pilkington, M.Inst.C.E., is responsible for the pioneer Anglo-American furnace hoisting and charging equipment (figs. 2 and 3) design. A reference to the illustrations (figs. 2 and 3) will show that American precedent has been closely followed. The capacity of the elevating gear is equivalent to the supply of the furnace with all the minerals necessary for the production of a weekly output of 1,500 tons, or 214

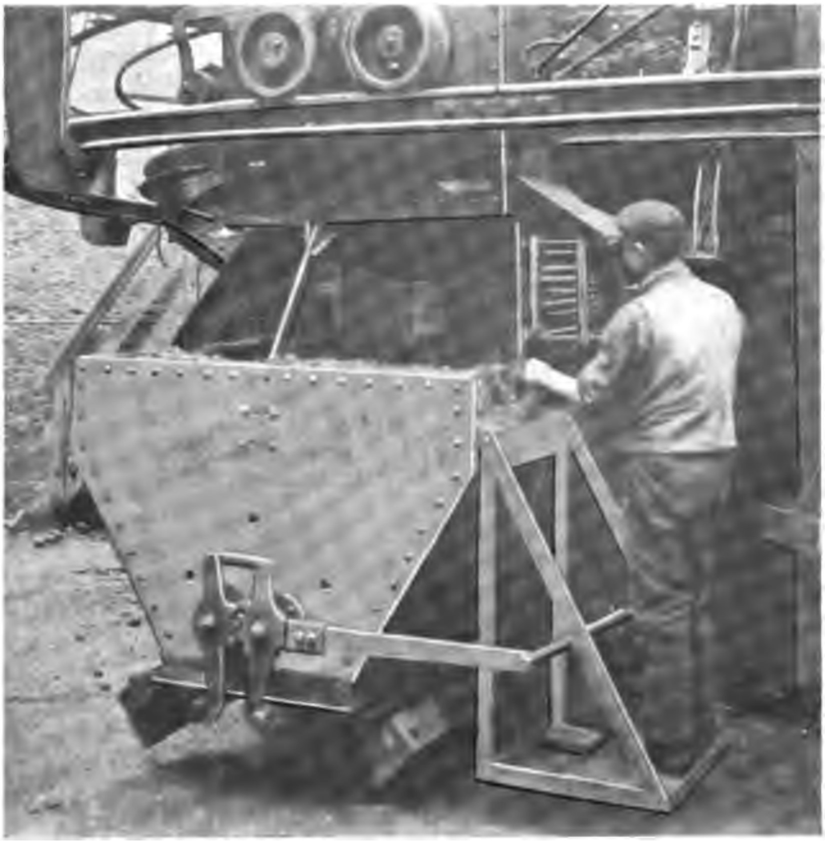

FIG. 4. THE ELECTRIC SUSPENDED CALCINED MINERAL TRANSPORTER—SHEEPBRIDGE COAL AND IRON COMPANY, LTD.

tons per diem. As the ratio of the minerals is 70 cwts. to each ton of pig-iron, and the equivalent of 25 cwts. of coke in addition, the full hoisting potential of the new Sheepbridge Coal and Iron Company's furnace is certainly a high one.

The mineral for the new furnace is stocked in a cupola calciner. Electric transport cars, shown in fig. 4, receive the mineral, and transport and hoist it to the elevator skip.

The charging arrangement is such that the mineral is dropped from the lip of the main bell in a regular stream, so that the mineral is evenly deposited into the furnace.

The entire transporting and elevating gear is electrically actuated by energy generated by the author's blast furnace gas-power system.

This is the pioneer English installation, in which the gas generated from the fuel in the blast furnace is directly utilised for generating dynamic energy, to be afterwards electrically transformed to transport the replenishing fuel and mineral to the mouth of the furnace. The same gas power generates the electric lighting energy as well. Great credit is due to Mr. Pilkington for his pioneering enterprise, which in some respects has secured a progress in advance of American practice. The blast-furnace gas-power electric generating station is shown in fig. 1.

Another British furnace which embodies in its design the American system of internal mineral transport and elevation, is that constructed by the Millom Iron Company, Ltd. The furnace manager, Mr. A. Sahlin, reports that he has succeeded in co-operating with his men so that the output is not limited, and everybody associated with the furnaces works for the best practice and for the largest output. Mr. Sahlin has been fortunate in being able to obtain the same free hand regarding labour as is enjoyed by the American ironmasters. He has succeeded in satisfying his employees that the principle of giving the reward for merit where it is justly due is better for their own well-being, and also for that of the firm, than is the cast iron ("ca canny") restriction of the British trade unionist control. Mr. Sahlin may have really done some service to this country, and it is quite possible that the records of the success of the Millom furnaces will provide an object lesson that cannot be explained away by the sophistries, however subtle they may be, of the labour agitators.

The latest application of the American mineral transporting systems applied to British furnaces is that illustrated in fig. 5, which represents the Brown hoisting and automatic stock distributing gear applied to the new furnace of the Palmer's Shipbuilding Company at Jarrow.

The following is a brief description of this up-to-date furnace, hoist, and automatic stock distributor. So completely automatic is the arrangement that one man in charge of the hoist can control its working. The inclined structure is built entirely of steel. All the bearings of the rotating parts are of the dust-proof pattern, fitted with large and easily accessible oil cells. The mineral distributor is heavily proportioned of cast iron, and rotates on a steel bearing, having a cylindrical gear that is actuated by a pinion mounted on a vertical shaft, which, by a suitable gearing and clutch, is connected with the main hoisting machine, and this in such a way that when the skip is actually being hoisted, the clutch is inoperative. When the skip is being lowered, the clutch is connected to and turns the distributor around a fixed angle.

The proportions of the skip are such that four full loads constitute a charge. The furnace bell-charging cone is built up of steel plates made up in sections bolted together, so that any section can be quickly dismounted and pulled away to permit the bell to be taken out, and to facilitate this operation the cone sections are provided with rollers. The cone is also provided with explosion doors, and on referring to the figure it will be noticed that the equipment includes an overhead travelling gear, which permits the charging bell to be changed in a few hours.

The capacity of the skip is 120 cubic feet, and the hoist equipment is capable of handling 1,300 tons of material per diem. The skip is built up of steel plates, eliptical in shape, and fitted with a false steel plate lining on the inside, so arranged as to be easily renewable.

HOISTING ENGINE.

This is of the non-reversible type, double cylinder, 12 in. in diameter, with 15 in. stroke, and is equipped with hand friction brake and powerful friction clutch.

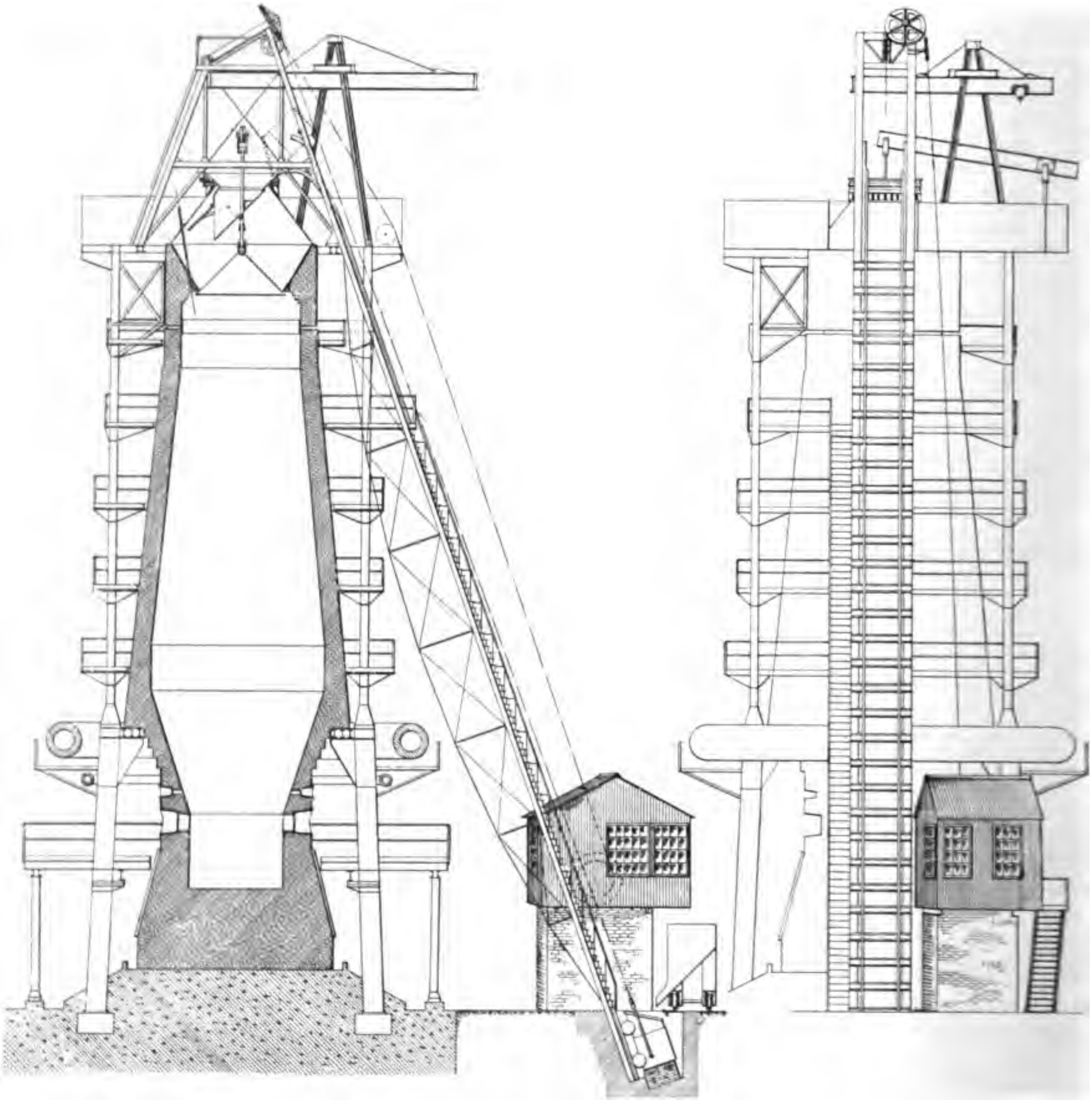

FIG. 5. BROWN HOISTING GEAR APPLIED TO THE NEW FURNACE OF THE PALMER'S SHIPBUILDING AND IRON COMPANY, LTD., AT JARROW-ON-TYNE.

TESTING THE HEIGHT OF THE FURNACE BURDEN, OR STOCK.

To enable the hoist operator to ascertain at any time the exact height of the burden of the furnace for the purpose of preventing under or over-charging, four rods are let into the top of the furnace (as shown in fig. 5) through suitable openings, and the rods are connected with dials located in the hoist operating house, so that as the rods are lowered into the furnace they visually indicate the exact height of the stock.

Another indicator located in the operating house consists of a graded dial connected to the bell by a light wire rope; its gearing is such that a drop of 1 in. of the bell corresponds to a 3-in. pointer deviation on the dial. There is also an automatic indicator for signalling the number of skips for each charge, the latter being operated by the hoisting drum. The dials of all the indicators are prominently located in the operating house well within the view of the hoisting engineer.

THE REMARKABLE OUTPUT CAPACITY OF MODERN AMERICAN BLAST FURNACES.

It would probably be difficult to find a more striking illustration of the effect of the modern and revolutionary changes effected in industrial procedure and apparatus, than that furnished by the remarkable records of the modern American type of blast furnaces.

Instead of a daily output of 90 to 100 tons, the record of an ordinary British blast furnace, we have sustained records of modern American blast furnaces attaining an output of 500 to 750 tons per diem, with less than 50 per cent. increase on a furnace of normal capacity in British practice. This phenomenal increase in output, compared with the comparatively small increase in plant, has of course secured a considerable economy in coke expenditure and in the general working costs of the furnace, per ton of output.

AMERICAN BLAST FURNACE RECORDS.

In these articles the author has no intention of discussing the various qualities or the chemical or metalliferous characteristics of the minerals fed into the furnaces, as there is abundant evidence in existence to show that American furnaces of identical capacity, using ores of similar metallic value, yield almost identical outputs. American furnaces, with blast pressure and blast temperature similar to those found in certain English furnaces, when supplied with iron ores having nearly equal metallic contents, have produced similar quantities of pig-iron of practically the same quality, so that the comparative characteristics of the mineral, or raw materials, whether in the United States or the United Kingdom, do not necessarily enter into the equation that explains the American blast-furnace record output.

For facility of comparison, let us tabulate the characteristics of (1) an ordinary British blast furnace; (2) a more modern British blast furnace; (3) an ordinary American pattern; and (4) an up-to-date type of American furnace.

Structural and Working Characteristics.	British. No. 1. Ordinary.	British. No. 2. Modern.	American. No. 3. Old.	American. No. 4. Modern.
Internal capacity of furnace in cubic feet	10,012	18,495	14,600	26,500
Total height of furnace in feet	60	85	75	106
Diameter of bosh in feet	18·5	20	20	23
Diameter of hearth in feet	10	11	11	15
Pressure in lbs. of air blast	5	7	5	15
Temp. of air blast, Fah.	1,100°	1,100°	1,100°	1,100°
Cubic feet of air blast per minute	10,012	17,263	16,000	50,000
Out-put of iron in tons per 24 hours ..	95	206	200	570
Weight in lbs. of coke consumed per ton of iron produced ..	2,350	2,206	1,912	1,780
Output of iron per sq. foot of bosh area in tons	0·354	0·656	0·636	1·37
Output of iron per sq. foot of hearth area in tons	1·20	2·168	2·10	3·23
Ratio of bosh diameter to height	1 : 3·24	1 : 4·25	1 : 3·25	1 : 4·60

From an examination of the tabulated data, the coincidence of the increased output of iron with increase of volume or weight of air supplied to the furnace is at once apparent—in fact, it will be realised that if the out-put of the British furnace No. 2 is multiplied by the volume of air employed for the American high record furnace No. 4, and *vice versa*, the difference between the results is practically unappreciable; showing that the master factor explaining the difference in the output of the two furnaces is the variation in the supply of air. The weight of the air actually fed to any blast-furnace is, of course, that equivalent to the displacement caused by the piston in its indrawing stroke in the blowing tub. The air pressures established, and shown on the engine-house mercury gauge, simply represent the aggregate of the effect of frictional resistance to the flow of the air in the air mains, recuperator hot blast stoves, and especially by the burden in the furnace itself. The author strongly recommends the employment of a pressure gauge on the horse-shoe mains of each furnace, if not at each one of the tuyeres.

The actual weight of air corresponding to the different volumes at atmospheric pressure and at 60 deg. F., or that of the air drawn into the blowing-tub, is for the different volumes as follows :—

	1.	2.	3.	4.
Volume of air per minute, cubic feet	10,012	17,263	16,000	50,000
Weight of air per minute, lbs. ...	754	1,317	1,225	3,815
Iron, output per diem, tons ...	95	206	200	570
Weight of air in lbs. per minute, per ton of iron produced per diem	8	6·4	6·2	6·7

Of course the pressure established on the air in the hearth of the furnace, even if it is within 2 lbs. of the maximum pressure shown on the gauge in the blowing engine-house, means that the density of the air must be greatly increased, and this means, in other words, a greater weight of oxygen contained in a given volume of furnace hearth space, and the combustion energy is *pro tanto* increased.

The pressure established at the furnace hearth is of course the degree determined by the resistance of the burden to the flow of the air. The diagram shown in fig. 6 demonstrates the effect of the increase of weight of air introduced into the furnace hearth in a given time.

The comparative increase of heat intensity is the measure of the vertical ordinates from the datum line to the point of intersection of the line corresponding to the volume, and, where it is crossed by the line drawn diagonally across the diagram. (N.B.) These units are merely those employed for graphic comparison.

Now take the equivalent unit of intersection corresponding to a volume of 28,000, and a pressure of 8 lbs., whereas the intensity that might be numerically expected to follow the doubling of the pressure and volume would be 8, it is actually 10, showing that the increased pressure has raised the intensity by 25 per cent.

HIGH PRESSURE FURNACES—THE ADVANTAGES OF HIGH AIR BLAST PRESSURE.

The diagrams given show clearly that the high air blast pressure (and weight of air equivalent) is the master cause of the splendid output records associated with modern American furnaces. The explanation is not difficult to find—it is the one common to all thermal operations, *i.e.*, the economy due to intensification of thermo-chemical operations. Whether the application is for the production of light or heat, the economy of concentration or high intensity is equally marked.

Given any cubic space in which it is proposed to establish a degree of heat intensity, it must be obvious that the heat will be a direct function of the weight of combustible actually burnt in a given time. The enclosing wall surface will be the same, whether one ton or five tons of carbon is oxidised in a unit of time, and the degree of heat energy generated will entirely depend upon the weight of air introduced in the unit of time, assuming of course that the carbon, say coke, is supplied in the equivalent proportion to the weight of air. The author here begs to suggest that the term "pressure and volume of air per minute" should be discarded, and that of "weight of air" should always be used. The character of the misconception amongst many blast furnace managers, due to the employment of the former term, will be understood when it is known that in order to secure a higher air-blast pressure at the tuyeres, the latter have been deliberately reduced in their diameter, thus increasing the frictional resistance. As this has been done without increasing the piston speed of the engine or the number of the tuyeres, the change

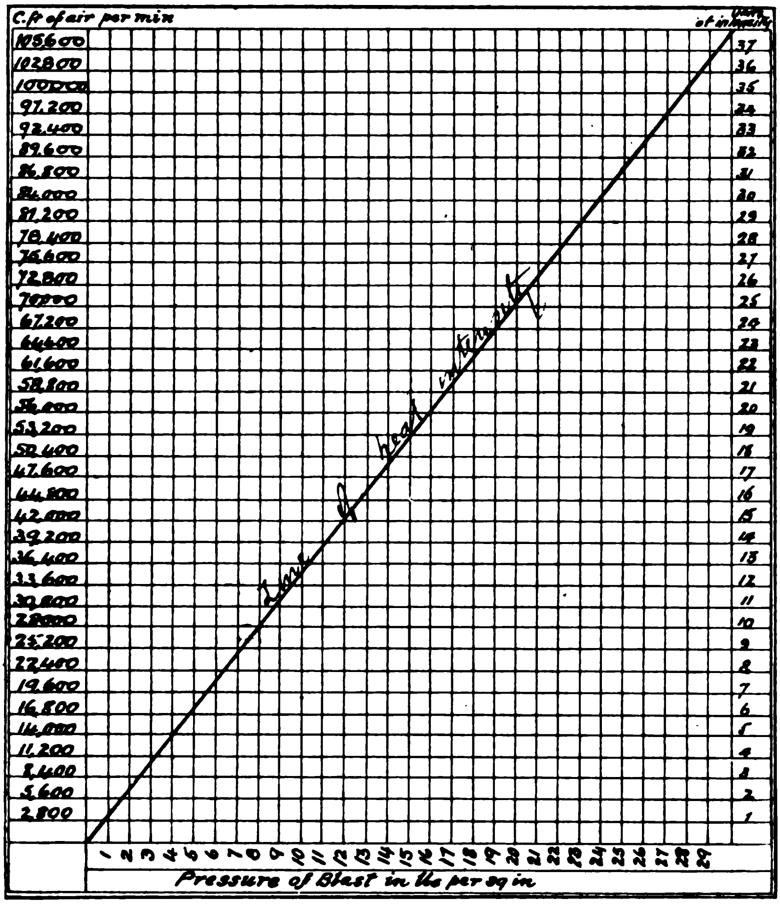

FIG. 6. DIAGRAM SHOWING THE CONCENTRATION OF HEAT DUE TO AN INCREASE OF PRESSURE (AND VOLUME) OF AIR IN BLAST-FURNACES.

has produced no benefit, but on the contrary an adverse effect, due to the air leakage caused by the increased pressure, and also to additional work being thrown back on the blowing tub piston. Of course, the result of this reduction of the tuyeres has reduced the output, much to the surprise of those responsible for the reduction of the tuyere diameter.

THE COST INVOLVED IN THE INCREASED WEIGHT OF AIR.

It has been conclusively proved that the master factor in the equation of blast furnace efficiency is the intensification of combustion energy in the furnace hearth and bosh, which means the supply of an increased weight of air and fuel in a given time.

Now, this increased weight of air involves, as an obvious consequence, the establishment of an increased air-pressure by the blowing engine piston, because it must be clear to the reader that if twice the weight of air is forced in a given time through the interstices of the more or less porous burden of a furnace, then the resistance to the passage of the air through the burden must be augmented *pro tanto*. Now this increase of resistance involves a greater expenditure of dynamic energy, but, as the author has already demonstrated in other papers, there is in the waste effluent gases flowing from the British furnaces a dynamic - power - producing potential far in excess of that necessary to secure the weight of air that can ever be demanded by a furnace under any possible conditions of economic and high capacity working.

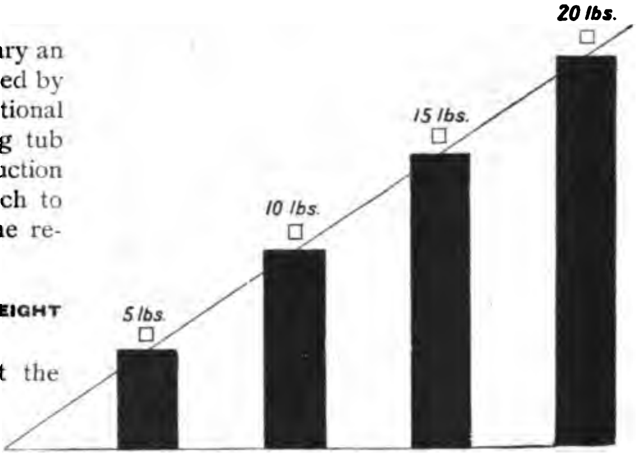

FIG. 7. GRAPHIC DIAGRAM SHOWING COMPARATIVE DEGREES OF CALORIFIC INTENSITY, DUE TO VARYING AIR BLAST DENSITIES EQUIVALENT TO THE DIFFERENT PRESSURES PER SQUARE INCH INDICATED.

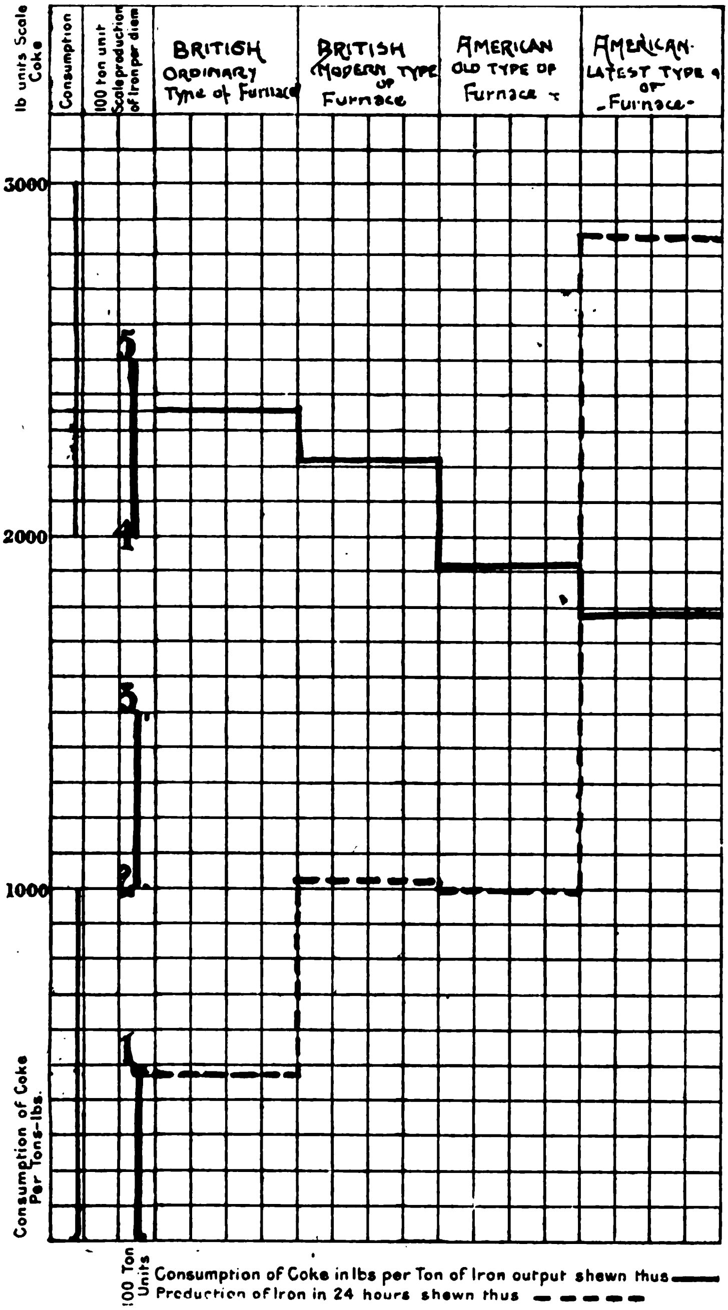

FIG. 8. GRAPHIC DIAGRAM SHOWING THAT THE DECREASE IN THE CONSUMPTION OF COKE HAS FOLLOWED THE INCREASE IN THE PRODUCTION OF PIG-IRON PER DIEM.

Of course, all steps towards an economic ideal should be taken cautiously (and this does not necessarily mean slowly), because it can be easily conceived that the variation in the character of a blast furnace burden, made up of special mixtures of ores determined by local conditions, and structural character of coke, will often require some special modification to secure the economic and output efficiency results desired.

The author is of opinion, however, that if the coke is structurally hard and firm, the charging arrangements satisfactory, and the number of tuyeres sufficiently augmented, nothing but progress towards economy of output can follow the increased supply of air, and thus bring the British furnaces into line with the up-to-date American ones.

STATIC STRUCTURAL CHANGES.

In providing an additional weight of air for existing furnaces, it must not be overlooked that the shells, or casings, of the hot blast stoves and gas mains should be adequately strengthened. In the new furnaces, the static structural features represent a great improvement upon those of the old type. Lattice work, and built-up steel girder columns for supporting the mantels have now replaced the old and clumsy cast-iron columns and mantels, thus giving more clearance around the hearth. In Germany, the more elaborate, if not fantastic designs, include light lattice columns, supporting platforms at various altitudes of the furnace shell. Probably a circular or ring form of platform, embracing the furnace shell, might with advantage be provided. If this platform were suspended and counterbalanced, and guided by vertical steel ropes in tension, it might also be raised and lowered for the purposes

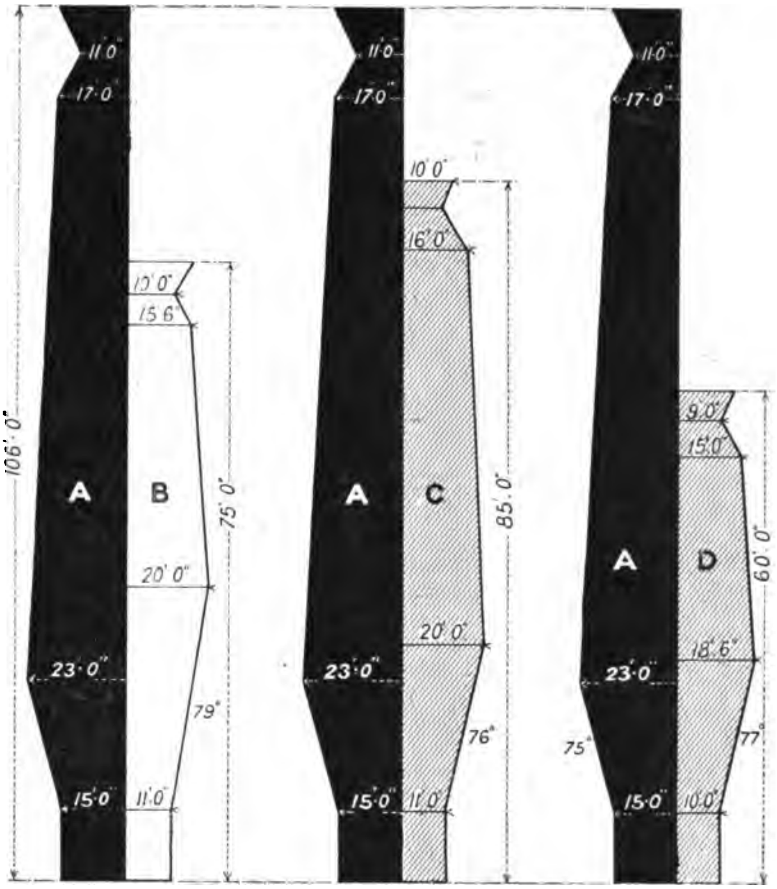

FIG. 9. THE PHYSICAL PROPORTIONS OF AMERICAN AND BRITISH FURNACES COMPARED.

The output of pig-iron per diem of 24 hours. In furnace marked **A** ..	570 tons.
That of **B** ..	200 ,,
,, **C** ..	206 ,,
,, **D** ..	95 ,,

A is the Up-to-date American Furnace. **C** is the Best Type British Furnace.
B ,, Old Type ,, ,, **D** ,, Old Type ,, ,,

of renovation, construction, and repair, and examination of the furnace and its shell.

EQUAL DISTRIBUTION OF THE AIR TO THE HEARTH ZONE.

With the increased weight of air supplied to a furnace hearth per minute the importance of a more complete distribution of the air ejection round the circle constituting the side wall of the hearth becomes apparent. Whilst the normal pressures of the British furnace meant only the introduction of some 300 cubic feet of air a minute per linear foot of hearth wall, the modern American hearth wall has distributed through it some 1,447 cubic feet of air a minute per linear foot of hearth enclosing wall.

To maintain the normal number of tuyeres common to the old type of furnace hearth with such an enormous air addition is clearly impossible, and consequently one finds that the number of tuyeres in modern American practice has been augmented, so that now a tuyere is placed in *every three linear feet of hearth wall circumference*, instead of (as in the normal British practice) 1 tuyere in every 5 or 6 ft.*

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* The author considers that even the modern American practice in distributing the air to the hearth zone is not satisfactory. He would develop the multiple tier system of applying the tuyeres, and instead of two tiers or rings of tuyeres he would employ three, alternating the position of the tuyeres, so that no tuyere has another directly beneath it. In this manner an almost perfect air distribution around the hearth zone would be obtained. Of course, the number of tuyeres and their disposition would be decided with proper regard to the structural requirements of the hearth jacket casing. By the arrangement suggested, an approach to the ideal distribution of air, by an annular aperture, would be realised.

Any attempt to increase the weight of air supply to existing British blast furnaces must include a new scheme of distribution of the air around the hearth. The employment of a greatly increased weight of air with the existing number of tuyeres would certainly be fatal to complete success.

FUEL OR COKE EXPENDITURE PER UNIT OF IRON PRODUCTION.

The effect of rapidity of combustion in reducing the loss of heat by side wall radiation is very marked. We know that, owing to the increased weight of air employed, the salient characteristic of the modern American furnace, the pig-iron output has been immensely augmented. Although the internal capacity of this furnace *per se* is only some 50 per cent. greater than that of the old type of British furnace, yet the output of the furnace has been augmented in the ratio of 6 to 1.

Another very important economy that American practice has secured, and one that the British people should appreciate, is a reduction in the expenditure of coke necessary to produce a given reducing and melting effect in the blast furnace, a result due to the increased calorific intensity and rapid reducing operations of modern American practice. (See graphic diagram, fig. 8.)

In the ordinary type of British furnace, an expenditure of 2,350 lbs. of high quality coke is required to reduce high quality ore, and to melt the product. In the American high capacity furnace this object is attained by an expenditure of 1,780 lbs. of coke, equivalent to a fuel saving of no less than 23·3 per cent. Even if this percentage of economy is reduced by 5 per cent. to allow for a possible higher metallic content in American ores, there is still an economy of 19·3 per cent. in the expenditure of coke. Now, to thoroughly understand the potential value of such an economy, let us apply the measure of it to the British yearly output for 1900, which equalled 9,300,000 tons. We will estimate the expenditure of coke to be the average expenditure in British furnaces and to be equivalent to 2,350 lbs. per ton of output, because, although the fuel consumption in many British furnaces is far higher than this, the mineral used in these furnaces has a far lower content of metallic iron. Now the British output for the year 1900 equalled some 9,300,000 tons of pig-iron. Therefore, the expenditure in coke is

$$\frac{9{,}300{,}000 \times 2{,}350 \times 19{\cdot}3}{2{,}240 \times 100} = 1{,}883{,}043 \text{ tons.}$$

If we take this coke as having a value of 15s. per ton, the gross annual saving will be £1,412,282, which is equivalent to the payment of 10 per cent. on a capital outlay of over 14 millions sterling—an amount that could certainly be justifiably expended in securing the 19·3 per cent. economy in the expenditure of coke per ton of pig-iron. No wonder that American ironmasters have become rich beyond the conceptions of a Crœsus.

The author is satisfied that even the remarkably low consumption of coke—the greatest tribute to the value of American practice—can be surpassed. There is still ample margin between the theoretic possible and the already attainable.

THE TUYERES.

Reference has already been made to the importance of supplying an adequate number of tuyeres for the even distribution of air to the hearth, and to the necessity for maintaining the efficiency of the tuyere as the means of its distribution.

The author considers that irregularities in furnace working, due to the inherent inefficiency of the tuyere system, have never been sufficiently appreciated. With the increased air-blast pressure, constituting the most conspicuous feature of modern American practice, the efficient maintenance of the tuyeres has become more and more difficult. There is, in the first instance, a heavier flow of air per unit of time, and a *pro rata* movement through the tuyere of a greater number of thermal or heat units; and, in addition, the intensity of combustion near the nose of the tuyere is far higher.

Consequently, it has been found in American practice, that to secure the rapid removal of the heat, which might endanger the life of the tuyere, copper—the metal *par excellence*—having the highest heat conductivity, is the most reliable one for tuyere construction.

THE VACUUM SYSTEM OF COOLING A TUYERE.

When a tuyere is burnt through, the aspiratory effect due to the flow of air involves as an incidental effect the aspiration of the

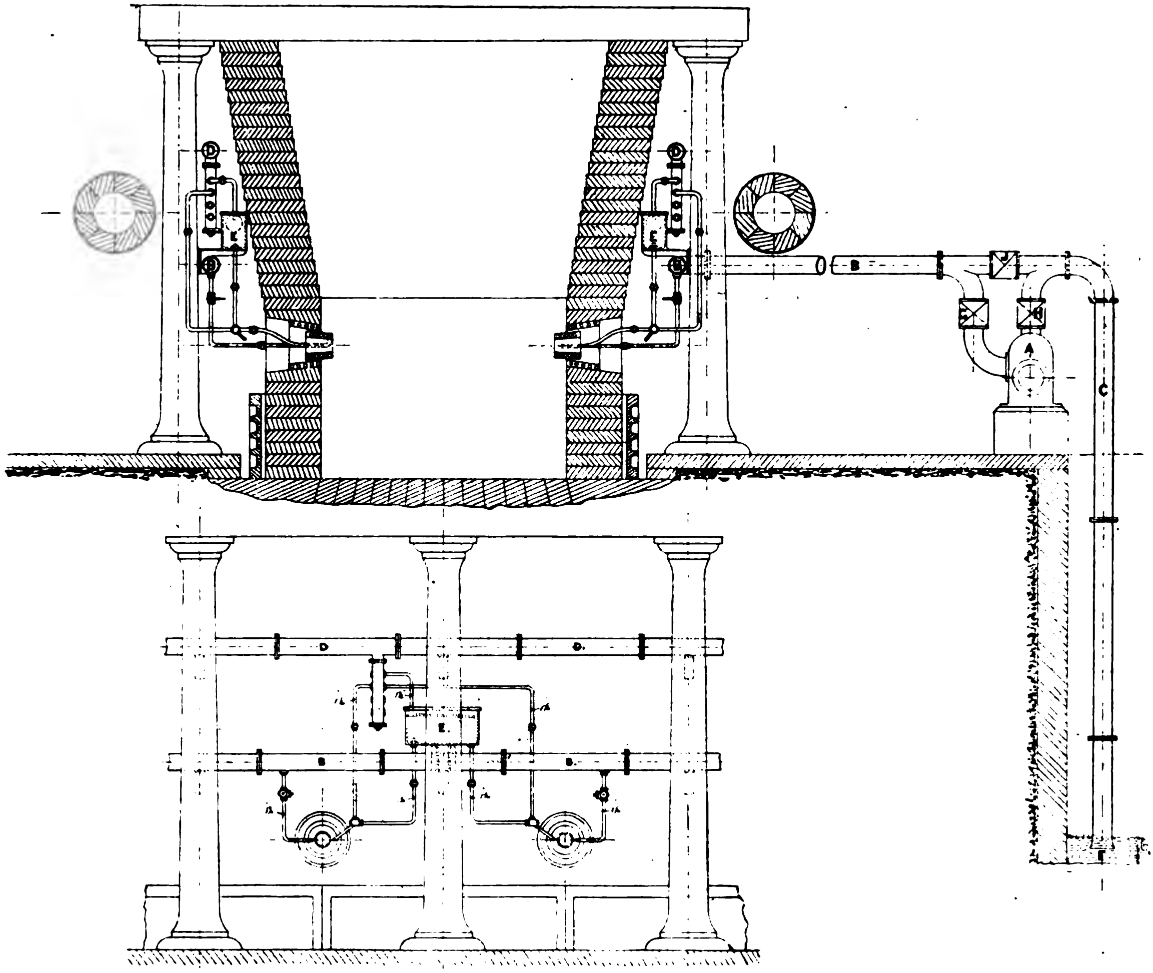

FIG. 10. ILLUSTRATION OF AN ARRANGEMENT FOR WORKING THE FOSTER TUYERE SYSTEM WITH SIPHON PIPE.

The vacuum is established by means of a pump, and the vacuum may be maintained after the pump is stopped by opening the valve **J**, and closing valves **G** and **H**. Reference to Figures :—

A	represents the Vacuum Pump.	**D**	represents the Water Service Pipe.	**G**	represents the Inlet Valve.
B	„ „ Suction Pipe.	**E**	„ „ Tuyere Water Tanks.	**H**	„ „ Outlet Valve.
C	„ „ Delivery Pipe.	**F**	„ „ Main Vacuum Seal.	**J**	„ „ Bypass Valve.

circulating water through the leak and its immediate ejection by the air into the furnace hearth. This results in the dissociation of the water, and with it a considerable absorption of the heat energy of combustion, and also the possible oxidation of the iron to Fe_3 O_4E—effects that should, of course, be avoided.

An ingenious and very promising attempt to overcome the defects of the pressure tuyere system has been made by Mr. Foster. Instead of relying upon positive or pressure agencies, to force the circulating water through the tuyeres, Mr. Foster relies either entirely on aspiratory energy, or partly on pressure and partly on aspiration, to produce such a culminating effect, that, in the event of an orifice being produced in the shell of the tuyere, owing to imperfect circulation, there is little or no tendency for the water to be sucked into the furnace.

The general arrangement of the application of Mr. Foster's tuyere is shown in fig. 10; a photo of an actual installation of the tuyere in a furnace at Darlaston is shown in fig. 11.

The vacuum tuyere system further provides an automatic associate that indicates both visually and orally when the tuyere commences to go wrong, and in time to enable the labour staff to reduce the degree of the disturbance of the working of the furnace. This automatic system, as designed by the author, consists in the provision for each tuyere of a mercury gauge, equipped with the platinum terminals of an electric circuit. When the aspiration in the water-supply main falls off through a leakage in the tuyere, the mercury in the gauge couples the terminals, causing a bell, gong, or steam whistle to sound, while a semaphore simultaneously indicates the number of the leaky tuyere. The water supply to this tuyere is immediately cut off, and the defective tuyere is at once replaced by a sound one. (See fig. 12.)

All well-equipped works are provided with some form of water cooler to reduce the loss by evaporation of the water used in the furnace cooling operations.

THE LINES OF THE FURNACE.

The intensification of the energy of combustion, with its sequence of more rapid reduction of the iron ore, has commensurately increased the speed of the descent of the mineral, and this accelerated movement has necessarily evolved some considerable variation in the form of the vertical cross section of the furnace. The measure of the variation from the old design will be readily understood on referring to fig. 9. In the diagrams half sections are shown of a modern American furnace, A, of of 570 tons daily capacity, with other furnaces, B, C, and D, the daily capacities of which are given in the illustration.

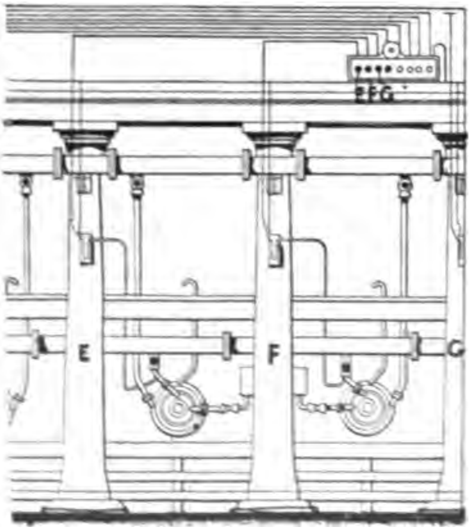

FIG. 12. FOSTER'S VACUUM SYSTEM.

Showing the Tuyere Automatic Electric Signalling Gear

It will be seen that the vertical angle of inclination of the bosh-lines varies from 78 deg. to 75 deg. and 76 deg. measured from the horizontal line.

It will be also noticed that the difference between the ratio of the height of the bosh, measured from the hearth line to the head of the widening slope, to the height of the furnace, of the new and old types of furnaces, is considerable. In the new furnaces it is about one-sixth of the height; in the early American, one-third; in comparatively modern British, one-fourth; in early British furnaces, it was one-third.

As the descent of the minerals in the new American type of furnace, with a daily output capacity of 570 tons per diem, is equivalent to the fall of 1,710 tons of mineral 106 ft. in twenty-hours or 4·42 ft. in one hour, it will easily be understood that the wear of the furnace lining is much more severe than it is in the older type of British blast furnaces where the descent is very sluggish. For instance, in a typical old style furnace of 95 tons daily capacity, 285 tons of mineral will fall 2.5 feet in one hour, so that the comparison in the rate of descent between the two furnaces is as follows:—$(1710 \times 4{\cdot}42) : (285 \times 2{\cdot}5) = 7585 : 712$ – or roughly the energy of descent is ten times greater in the new American type than it is in the old type of British furnaces. This descending movement is enclosed within a lining wall circle of nearly the same linear dimensions, therefore it might naturally be expected that the bosh and hearth lining of the new furnaces would be rapidly worn away by abrasion or attrition of the minerals in contact with lining surfaces at high temperatures.

The American constructors, with characteristic boldness, have faced this difficulty by the application of a furnace-lining cooling system that has most conclusively established its efficacy—a quarter of a million tons of pig-iron have been run from the same furnace (equivalent to the descent of at least one million tons of minerals) without involving more than one relining operation.

The following is a specification of the main features of the American system of furnace structure cooling: The bosh lines are maintained sufficiently cool by the employment of ten rings of bronze coolers. Cast iron coolers are located above the upper bronze rings. Two bronze coolers are also installed below the tuyeres. (See illustration on page 382, September number.) It is also even suggested that the throat of the furnace should be water-jacketted.

In one typical American blast-furnace installation seven millions of gallons of cooling water can be circulated through the lining coolers and tuyeres in twenty-four hours. In order to establish a continuous head of water to maintain positive circulation, the water is initially delivered to a standpipe 150 ft. in height, with an internal diameter of 12 ft. Auxiliary pumps of a simple plunger type are provided as standbyes. A positive pressure of water equal to 25 lbs. applied to the cooling system below the mantels is maintained. The cooling system above the mantel is merely fed by gravity flow.

The hearth linings are externally encased with steel castings, over which sprays of water are constantly flowing;* and in addition, the casing carries a coil of pipes, through which water is rapidly circulated.

All the small water connections are equipped with ball and socket unions of the best quality. It is false economy to provide water fittings of inferior character, although this is not an uncommon feature in some furnace equipments.

THE MAINTENANCE OF INNER SURFACE OF FURNACE LINING.

It is well known that if a furnace works well—this means that the air flows uniformly through the burden of the furnace—there is a constant deposition of finely divided carbon in the reducing zone. Some of this forms a coating over the surface of the furnace lining, and thus constitutes a great protector against the influence of the effect of oxygen on the siliceous material with which the hottest parts of the furnace are lined. This carbon lining is of great importance, for on its own maintenance depends the successful uniform working of the furnace, and the preservation of the furnace lining. It will, however, easily disappear under the influences of attrition and oxidation, and therefore a durable artificial substitute would be very valuable. The author suggests that such a lining surface might be obtained by coating the inner or exposed surface of the lining bricks with silicon-carbide or carborundum. There may be some little difficulty in applying the material *in situ*, but the author thinks it would be surmountable if a serious attempt to carry out the idea were made.

THE REMOVAL OF THE SLAG.

The common method in modern furnace practice is to remove the slag by means of bogie ladles, which are so constructed that the mass of slag can be bodily tipped out of the ladle with the least possible residue of skull on the sides or bottom.

In furnaces producing a basic slag, it is a common operation to granulate the slag for agricultural purposes by immersing it in water whilst in a fluid state. Another example of the use of fluid slag is the production from it of a fibrous product, known commercially as slag-wool. Of course the appropriate commercial utilisation is determined by the chemical characteristics of the slag.

Attempts are being made, and with considerable promise of success, to use blast-furnace slag as the basis for the production of a commercial cement, approaching that of Portland.

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* The following are some of the structural characteristics of a modern furnace lining: Light cast iron or steel rings are fixed on the upper level of the furnace to protect the stock lining inside surface walls from the effect of violent impact of falling minerals. In addition, the stock lines are protected with several rings of cast iron segments. The mantels supporting stock lining are built of ⅜ in. steel plates with two courses of ½-in. plate, one over and one under the mantel.

ARE BRITISH RAILWAYS INSOLVENT ?

BY

CHARLES ROUS-MARTEN.

The Author, from an entirely independent standpoint, deals with the interesting controversy opened by "An American Railway Official" in the *Times*.

A CURIOUS and highly interesting controversy has been started by the *Times*, having for its subject the problem whether the railways of Britain are or are not insolvent. It was opened by a contributor, described as "a writer who having begun his railway career in this country, has attained an important position on the wider stage of the United States." He styles himself simply "An American Railway Official." His attitude is thus indicated by the *Times*: "Broadly, he throws doubt on the solvency—we might almost say he proclaims the insolvency—of English railways as a whole, and the English public have invested in English railways a capital about twice the whole National Debt." Clearly then, the question at issue is a very large one.

The "American Railway Official" begins insidiously with praise of a certain American railway—the Delaware, Lackawanna and Western Railway Company—which, to save space, I will take the liberty of referring to henceforward as the D.L.W. line; but he soon discloses his actual programme, which is a comparison between "the methods in vogue on an American and on a British line." He selects the North-Eastern as the special British example, and he compares its figures for the latter half of the year 1901 with those of the American railway just mentioned, for the same period.

THE NORTH-EASTERN RAILWAY CRITICISED.

After setting forth a formidable array of figures quoted from the respective balance sheets of the two companies, he sums up the North-Eastern result as follows: "It is evident from what has been stated that its current operating charges were relieved at the expense of capital, that this process has been going on for so many years that the corporation is suffering from over-capitalisation, and what was begun, perhaps as a temporary expedient to pay a large dividend, has become a chronic necessity. The half-year's balance-sheet shows the progress of the disease. With a decreased income of £60,875 for the half-year, its managers charged to capital on account of lines and works open for traffic, £284,973, and for working stock (carriages), £96,117; total, £381,090, the equivalent of fully 2½ per cent. of its dividend." And he deduces the conclusion that "the company could not fairly pay the balance of 3½ per cent. if it had dealt properly with the revenue account, and charged it with all necessary outlay to maintain the road, works, and equipment up to the high standard of efficiency necessary for safe and economical working. This has been shown from its own figures, and is doubly clear when contrasted with the policy of a railway company managed on ordinary business principles."

A "MODEL" AMERICAN LINE.

The "American Railway Official" finds it "refreshing indeed" to turn to the report of the D.L.W. line. "According to that report," he says, "operating expenses are charged with 3,304,253 dols. (£660,851) for maintenance of way and structures. Included in this is 'the cost of various renewals, improvements and additions of an unusual character, aggregating the sum of 1,228,953 dols. (£245,791).' Of this amount, 259,847 dols. (£51,969) is for new bridges; 121,707 dols. (£24,341) for interlocking and signal apparatus; 329,337 dols. (£65,867) for sundry sidings, yards, and track; 110,750 dols. (£22,150) for new depôts, freight houses, etc.; 95,240 dols. (£19,048) for water and fuel stations; 84,670 dols. (£16,934) for new turntables, round-houses, pits, engine-houses, etc., and the balance of 227,402 dols. (£45,481) for sundry changes and improvements in buildings, new buildings on the line, and yards and sidings in course of construction. In addition to the item of 259,847 dols. (£51,969) for new bridges, there was expended and charged to renewal (not capital) account the sum of 1,007,255 dols. (£201,451), being the amount paid during the year for new steel bridges erected at different points on the line to take the place of old ones which were light and unsafe for the company's present traffic."

THE "PROFLIGACY" OF BRITISH RAILWAYS.

A lengthy quotation from the report follows, showing that many charges which, according to the "American Railway Official," are in England charged to capital, were on the D.L.W. line paid out of revenue. He thinks this is "a strong impeachment of British management," and he asks "How many British lines, for example, could follow such a course as the Lackawanna Company, and continue to pay anything like the dividends they have been declaring for years, or how many could pay any dividend upon their present capital?" He goes on to say: "The situation is all the more serious from the fact that it has crystallised into a recognised practice of British boards of directors to place everything that can be characterised as extraordinary expenditure into the capital account, as well as a great deal that cannot, even under the most liberal interpretation, be so classified. This has been in vogue for 30, nearly 40 years—ever since the prevailing form of railway accounts was prescribed, which gave an apparent invitation and colourable sanction to the prevailing procedure. Financial demoralisation has been and is rampant," and he asserts that "the increase of capital has frequently not even the apparent excuse for increase of revenue." He declares that the policy pursued is a profligate one, and that while such a policy prevails there can be no economies brought about, the incentive to such economies being wholly wanting. He holds that the end must be "that the railways of the United Kingdom will get further and further behind the times in economical equipment and up-to-date transportation methods, in addition to being handicapped with a rapidly accumulating capital debt, to gain any return upon which it will be necessary to charge unreasonable rates and fares, instead of continually reducing charges as in the United States."

THE "TIMES" SUMMING UP.

In the same issue of the *Times* this article is editorially dealt with. After virtually accepting the conclusions of the "American Railway Official," and summing up his main contention as being that "in the period which he reviews, the North-Eastern paid its dividend only by charging to capital £380,000 for improvements to already existing lines, and that the Lackawanna paid its dividend only after it had debited to net revenue £430,000 for extraordinary betterments of its property," the *Times* goes on to say: "The management of an ordinary business assumes that it is not sufficient to maintain the buildings and plant in condition out of revenue. Sooner or later, plant, even if maintained in first-rate condition, must become useless, either because it is superseded by newer inventions, or because it is, by change in demand, made wholly superfluous. There must, therefore, be in some shape or form a substantial reserve, or the company is likely some day to get into the Bankruptcy Court."

In fact, the *Times* holds that the British railway companies are "steadily working out their mine," and that even if they maintain their property out of revenue they have no reserves out of which to supplement or improve it, and it is contended that "a policy of this kind, if continued indefinitely . . . must ultimately lead to the extinction of dividends on the ordinary stock."

A PRACTICAL SUGGESTION.

Then, suddenly, the *Times* diverges from this point of financial policy to deal with a question of working, which has also been aired in its columns by "A Correspondent." After admitting that "the salvation of English railways will hardly be found, as not a few somewhat superficial critics have fancied, in big bogie-cars," it expresses the opinion that there is "more of practical interest" in its correspondent's contention that: "At a cost relatively trifling, with an almost equally trifling disturbance of existing and deep-rooted habits of trade, our existing four-wheel coal-trucks could be made to carry a load fully half as heavy again as at present, with a resulting economy which a competent critic thinks might run into millions per annum."

A CLEVER PIECE OF SENSATIONALISM.

These various criticisms have been met by Mr. George S. Gibb, the general manager of the North-Eastern Railway Company, who in an exceedingly able reply exposes several rather vital fallacies in the "case for the prosecution" of his railway, and also sets up a very skilful "case for the defence." He characterises the "American Railway Official's" article as "a clever piece of sensationalism," and as largely in the nature of "*suggestio falsi*." He points out that the year 1901 was the most prosperous one in American railway history, and that the D.L.W. line had a specially large share of the prosperity, wherefore it used its extra profits from the railway, and from collieries which it owns, to defray "certain expenditure which otherwise might properly have been charged to capital." Mr. Gibb also shows that, whereas the D.L.W. line spent only 8·8 per cent. of its gross revenue on "maintenance of way and structure," or at the rate of £437 per mile, the North-Eastern spent thus 10 6 per cent. of its gross revenue, or £584 per mile, while the sum of £201,451 for new bridges, also charged by the D.L.W. line to revenue, was (according to the president of that line) for "new steel bridges to take the place of old ones which were light and unsafe for the company's present traffic."

CHEAP CONSTRUCTION IN AMERICA.

In this connection Mr. Gibb remarks: "It is notorious that in original construction the American plan was to build railways on the cheap, good enough perhaps to begin with, but not to last for long. Such work must be renewed soon and often. Curves were left to be straightened afterwards, grades to be reduced, bridges to be rebuilt, and so forth. The work on most high-class English railways was of a different character—solid, costly, with immense reserves of strength, built almost for eternity, and not requiring constant renewal. But all well-managed English railways with which I am acquainted provide fully out of revenue for all necessary renewals."

Further, with reference to the American railway's expenditure on betterment, Mr. Gibb observes that it "includes the cost of 79 new engines, at an average cost of £2,550 per engine, but they had to break up or sell 72 worn-out engines, so that the net result of it all was that they added seven engines to their stock, debiting nothing to capital." But he adds: "The North-Eastern, in the same year, added 21 engines to their stock at an average cost of £2,693 per engine, in addition to making provision for ordinary renewals, the old engines being replaced in all cases by new and more powerful engines, and also without debiting capital with any part of the cost."

THE FINANCIAL PRINCIPLES INVOLVED.

Finally, Mr. Gibb deals with the standard of financial principles involved, which, he remarks, the "American Railway Official" has carefully abstained from defining. But the able general manager of the North-Eastern Railway frankly joins issue with his critic as to the implied argument that present-day shareholders are to lie-out of their reasonable returns in order to provide fat dividends for their successors in future years. He says: "If a shareholder owned £10,000 stock in the assumed undertaking in 1870, yielding him an income of £600 per annum, why should he then consent to an immediate reduction of his income because he foresaw that 30 years afterward the holder of his £10,000 stock would only be receiving £460 per annum? He would also foresee that the shrinkage in net profits would be due to the operation of general economic causes, and that these causes would operate on commercial and industrial undertakings all round, and also on prices, and that consequently an adjustment would to some extent take place in regard to the real value or purchasing power, as well as the nominal figure of the income. Why, therefore, should a shareholder of one generation pinch himself in income in order to provide that the shareholder of a later period should have an income at a nominal percentage on his capital higher than the percentage prevailing at the time throughout industrial and commercial undertakings of equal stability?"

THE CONTROVERSY FROM AN OUTSIDE STANDPOINT.

Now, as a professional observer, wholly independent of all railway companies and unconnected with any, having, moreover, enjoyed somewhat special opportunities of studying railway working in many parts of the world, I have been invited to comment upon the case as it is put forward respectively by the two parties to this discussion — the "American Railway Official" and the *Times* on one side, and the North-Eastern general manager on the other.

It would be alike idle and tedious to debate every item in the two armies of figures so ably set in array by the combatants. Yet, unless this be done, any detailed discussion must needs rest upon a hopelessly vague and shifting basis. For, be it observed, both sides are agreed that while all expenditure for mere renewals ought to come out of revenue, some charges for "betterment" may fairly be paid out of capital. Thus, the sole question at issue under this head is one of degree. How much? And this is just one of those questions which cannot be answered offhand by the formulation of any axiom. The case is very much on all fours with that of

THE GREAT BOGIE WAGGON REMEDY,

which some critics fondly believed to be the supreme panacea for all railway financial ills. "Carry your goods and minerals," they urged, "in big bogie waggons, holding thirty to fifty tons each, and then you will reduce your proportion of non-paying dead-weight and utilise your lines to great advantage." That view was perfectly sound as applied to some cases. If British railway companies had only to convey complete trainloads over vast distances, as in many American cases, the large waggon fully loaded would be undoubtedly the best and most economical. In such a case as that of the Caledonian Railway, which runs heavy trainloads of minerals that remain virtually unbroken throughout a long journey, the big waggons are manifestly desirable. But when, to suit the requirements of customers, trainloads have to be made up of innumerable relatively small consignments which must be left at almost as many wayside stations as there are vehicles in the train, or even if left in big batches at particular stations, must be readily divisible into separate truck-loads for the convenience of the respective consignees, then the huge 30- or 50-ton waggons would be a costly nuisance—the reverse of a boon.

THE AMERICAN PLAN OF BUILDING CHEAPLY.

So with many points in locomotive practice: The American plan of building cheaply and quickly, getting all possible work out of an engine during its life, and using it up unsparingly so that at a relatively early period it may be replaced by a newer and better machine, has its advantages in some respects; its disadvantages in others. I endeavoured to set out both sides of that case in a paper which I read before the Society of Engineers on June 2nd last, of which copious extracts bearing upon this particular point were published in the July issue of PAGE'S MAGAZINE, pp. 113-115.

INADEQUATE BOILER POWER.

The chief defect in the working of British railways as compared with that of the American and European Continental lines—viz., glaringly inadequate boiler-power, which so long hampered their usefulness, and which, by compelling duplication and excessive piloting, so seriously augmented the expenses and at the same time diminished the carrying capacity of the lines, has during the past few years been generally recognised. Efforts now are being steadily made to atone for past shortcomings in this particular, and to provide locomotives of power sufficient to perform the duty required of them. The financial fruits of this valuable reform will be garnered more and more in the form of decreased expenses as years go by.

RENEWALS FROM REVENUE.

But if the case be open to argument and to difference of opinion on points of working, it is even more so on the question of finance. A disputation might be raised over almost every item of outlay on improvements. Probably no leading British railway will dream of disputing the general principle that all expenditure on what is strictly the renewal of permanent way or rolling-stock already constructed out of capital, should be defrayed out of revenue. If ten old engines be condemned and ten new ones built to replace them, the charge is, as a matter of course, on revenue in the case of every properly managed line. But Mr. Gibb tells us that not only is this done on the North-Eastern Railway, but also the old locomotives are replaced out of revenue by others of much greater power. Consequently the ten old engines are replaced by new ones with the equivalent power of twelve or perhaps fifteen old ones. So, too, in the case of the road. It is manifestly advisable that when an inferior old permanent way is replaced by a better new one, this expense should come out of revenue.

THE INTERESTS OF POSTERITY.

But the *Times* appears to go farther than this, and to contend that "it is not sufficient to maintain the buildings and plant in working order," and that the British railway companies ought to "supplement or improve" their property out of revenue, as well as maintaining it from that source. But surely if a railway company goes in for "supplementing or improving" its property, when this process travels beyond the mere substitution of modern adequate buildings and plant for what is inadequate and old and worn out, it is undertaken for the purpose of being able to deal with increased traffic, that is to say of enhancing the earning-power of the line. Now if this be done out of a special surplus of revenue, yielded in an exceptionally favourable period, it is excellent policy and one which most shareholders would approve, it being preferable to apply a temporary excess of revenue to the permanent strengthening of the company's position rather than to distribute it in abnormally high dividends which could only last a year or two, and the reversion from which to normal rates would cause disappointment and inconvenience. But when dividends are cut down, or even "passed," and the money thus available is not devoted to ordinary renewals of permanent way, buildings, and plant, but is employed in making provision for conjectural future traffic extension, this surely involves a grave present injustice, however much posterity (which, as the Irish orator remarked, has done so little for us) might benefit in the future.

AMORTISATION RUN MAD.

It seems to me amortisation run mad. A railway is a purely commercial enterprise. It is carried on by its proprietors, the shareholders, simply for their own personal profit. No commercial business could be carried on if its proprietors were required to devote the whole of their profits to preparation for future problematical extensions of business which might quite possibly occur, but which, if they did occur, would return a good profit on such fresh capital as might be needed for such provision. Why should the living shareholder be pinched and starved in order that posterity may enjoy alone benefits which he himself may never share, although he has "borne the heat and burden of the day?"

A STRONG CASE FOR BRITISH LINES.

In my opinion Mr. Gibb has made out a very strong case. He has not been content with a mere dialectic victory, but has combated with solid fact and reason a somewhat one-sided and partial argument, based upon circumstances that are shown to be special and exceptional. He is all the better qualified for the championship he has assumed, inasmuch as he and his very able and progressive colleague, Mr. Philip Burtt, the general traffic manager of the North-Eastern Railway, have a remarkable record to their credit in respect of valuable reforms effected in the administration of the great railway which they control. Railway shareholders need not be alarmed by the lurid picture presented by the "American Railway Official" so far as it depends upon the grounds set forth. That railways, like all other traders, are exposed to the vicissitudes of weal and woe which necessarily affect all trades, and which are an inherent and inevitable condition of commerce, is, of course, indisputable. They may have bad times and good times; they may be managed better at one time and worse at another; there may be room in many respects for administrative and operative reform and improvement, but the spread-eagle pronouncement of impending ruin is the mere product of a lively—or, rather, deadly—imagination, stimulated by the fallacious fancy that circumstances do *not* alter cases, that a single medicine must of necessity be good for every complaint, and that the same rule must necessarily apply to all situations, however different one from another.

HOW BRITISH RAILWAYS ARE FLEECED.

But while the alleged insolvency of British railways on the grounds instanced is a pure myth, it is undeniable that these railways do labour under one special and exceptional disadvantage, and that is the monstrous and excessive extent to which they—unlike all other business concerns—are mulcted, or rather fleeced, in respect of taxation. The local rating of British railways is a disgrace to the community, because it is a glaring and scandalous use of power for the purpose of legal oppression. Railways are gleefully plundered by many local authorities through whose territories they have the misfortune to pass, and this operates with grave disadvantage to the interest of the public as well as to that of the railways themselves, for it not only in some cases levies a dividend when none is received by the owners, but also prevents greatly needed renewals or improvements being carried out because the companies are aware that such improvements would constitute an immediate pretext for raising the rateable value, and therefore a company has to provide not merely for the cost of the improvements or the interest thereon, but also a further sum for the increased rating that will be levied in grateful recognition of such improvements made for the public benefit. Many outside critics who rail at railway companies for not making improvements which are admittedly desirable, might well bear in mind the disagreeable condition involved, viz., that such improvements would mean additional liability on the part of the shareholders to what is in a large degree a legalised blackmail. At present railway improvements are subject to a heavy and strongly deterrent penalty.

Let railway shareholders, therefore, seek to obtain some measure of relief on this head, and let them ever watch keenly and probe relentlessly the whole administration of their concerns, not only financially but also generally, for there are doubtless many reforms which are both desirable and feasible. But let them not be terrified by "wild and whirling words."

BUSINESS SYSTEM AND ORGANISATION.

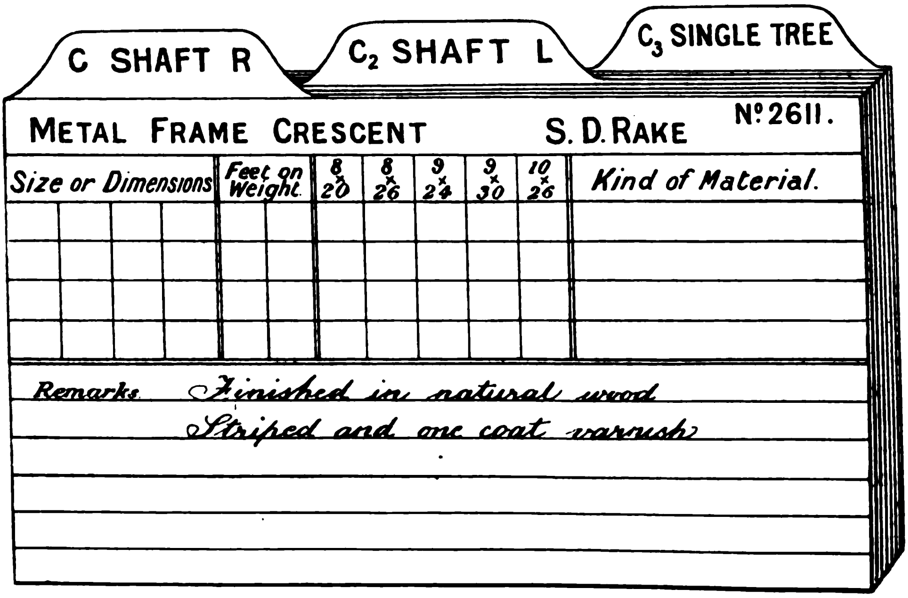
BY

D. N. DUNLOP.

III.—THE COST OF PRODUCTION.

We must now consider one of the main factors of industrial success—a simple but efficient system of ascertaining accurately the cost of production of every article manufactured. By this means alone can economy in production be ensured, and a profit fixed which will not turn out to be fictitious when accounts are balanced at the end of the year.

Many manufacturers have failed to solve the problem of how to secure accurate factory costs. In the fierce war of industrial and mercantile competition now being waged at home and abroad, the manufacturer is often tempted to



C SHAFT R | C_2 SHAFT L | C_3 SINGLE TREE

METAL FRAME CRESCENT S. D. RAKE No. 2611.

Size or Dimensions				Feet or Weight		8 x 20	8 x 26	9 x 24	9 x 30	10 x 26	Kind of Material.

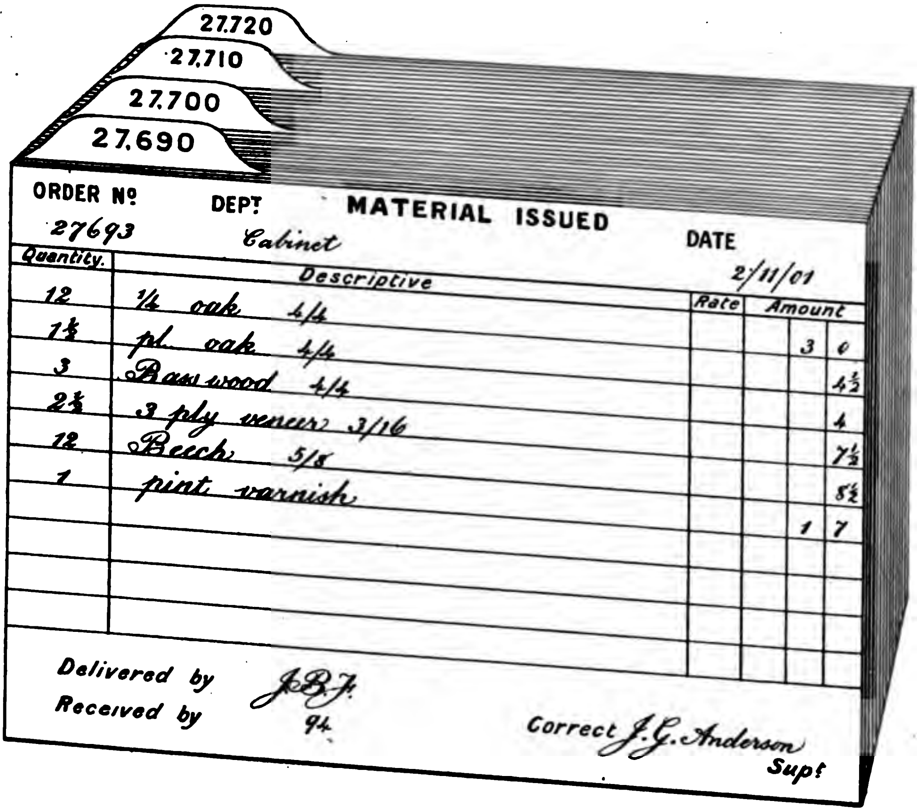
Remarks Finished in natural wood

Striped and one coat varnish

FIG. I. MATERIALS CARD.

MODERN BUSINESS ORGANISATION.—Record keeping in every conceivable form and direction is a most powerful adjunct to organisation and control in the workshop and office, and we propose to insert from month to month suggestive articles, which will indicate concisely the methods necessary to secure definite and practical results.

The following have already appeared: (July.) Prime Cost (17 forms).—By Claude W. Hill, A.M.Inst.C.E., M.I.E.E. (July.) Business System and Organisation.—By D. N. Dunlop. (Aug.) A simple system of Cost-Keeping (4 forms).—By D. N. Dunlop. (Sept.) Standing Charges (6 forms).—By Claude W. Hill, A.M.Inst.C.E., M.I.E.E. (July.) Hints on Advertising.—By Edward E. Matheson, M.Inst.C.E. (Oct.) Estimates.—By Claude W. Hill, Assoc. M Inst C.E., M I.E.E.



27,720
27,710
27,700
27,690

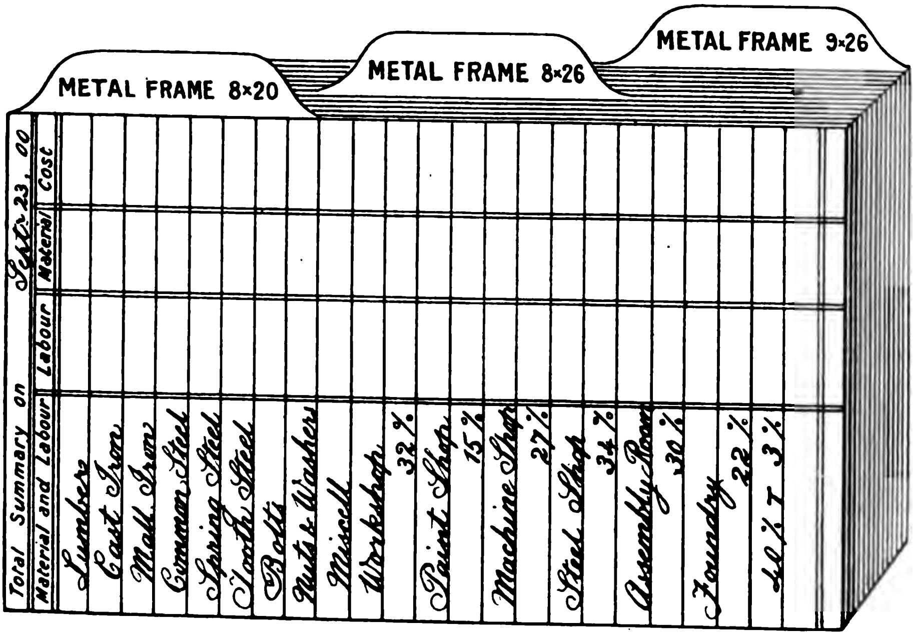
ORDER Nº 27693 **DEPT** Cabinet **MATERIAL ISSUED** **DATE** 2/11/01

Quantity.	Descriptive	Rate	Amount	
12	¼ oak 4/4		3	0
1½	pl. oak 4/4			4½
3	Basswood 4/4			4
2½	3 ply veneer 3/16			7½
12	Beech 5/8			8½
1	pint varnish		1	7

Delivered by J.B.J.
Received by 94.

Correct J.G. Anderson Supt.

FIG. 2. MATERIAL SUMMARY CARD.



METAL FRAME 8×20
METAL FRAME 8×26
METAL FRAME 9×26

Total Summary on Sept. 23, 00

Material and Labour	Labour	Material	Cost
Lumber			
Cast Iron			
Mall. Iron			
Common Steel			
Spring Steel			
Tooth Steel			
Bolts			
Nuts & Washers			
Miscell			
Workshop 32%			
Paint Shop 15%			
Machine Shop 27%			
Steel Shop 34%			
Assembly Room 30%			
Foundry 22%			
40% T 3%			

FIG. 3. ASSEMBLED COST CARD.

use the sale prices of his rivals as a basis for his own, without reference to his factory costs, and they are, perhaps, at best but approximately calculated. This practice is unsound and dangerous, for the sale price in every factory should be dependent on nothing so much as internal organisation and progressive methods, which are, as a rule, jealously guarded and kept secret. The fall in the sale prices of any soundly organised competing firm must be due either to economy in production or to increased output, which is the goal towards which all enterprising manufacturers strive by every means in their power.

The principal items upon which depends the cost of production in a factory are: material, labour, manufacturing expense, general expense, and special items of cost. The simple system here outlined has been tried with great success by prosperous American and British firms. In this system three costs are kept: (1) The *flat cost*, including material and productive labour; (2) The *factory cost*, which consists of the flat cost with the addition of non-productive factory labour, manufacturing expense, and all other expenses directly due to the factory; (3) The *total cost*.

In order to work this system a clerical force of seven will be found sufficient, viz.: a head account-keeper and his assistant clerk, a stores-keeper, the cost-keeper, and the time-keeper, who may, when the labour roll is a long one, require a clerk. Of these, only the cost-keeper can be charged to the new system.

COST OF MATERIALS.

Material forming the basis of manufacture claims the first consideration. By means of the records of the stores-keeper (as indicated in the last article) the exact amount and cost of all material used for every part and for the whole article manufactured can be easily ascertained. On material being requisitioned by a department, a separate card is issued by the stores-keeper for each article; it bears on the tab the name of the part for which it is to be used, and as heading the name of the article; in columns below are stated the size, weight, and kind of material, and finally a space is left for remarks, as to the finish ultimately given.

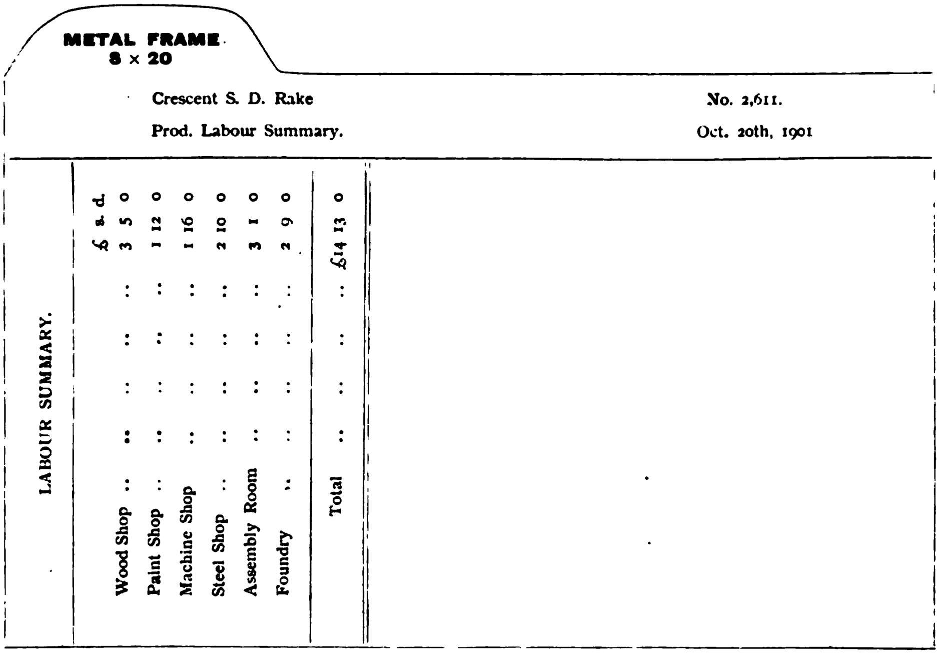
Some firms use the reverse of the card for a statement of the labour required for the same part, thereby forming a complete record of production. (See fig. 1.) A Material Summary Card (see fig. 2.), compiled by the cost-clerk from the various cards issued from the stores, supplies the total cost of material for the part. This card, sent to the department for confirmation, bears the initials of the stores-keeper who delivered the goods, the number or punch of the foreman who received them, and the signature of the superintendent, affixed on completion of the work, after which the card is forwarded to the cost-clerk in the office. On receipt of similar cards from the departments through which the part passed in the process of manufacture, giving the various items of labour and the manufacturing supplies for the week, the cost-clerk compiles a total summary of material and labour for the whole article, known as the Assembled Cost Card. (Fig. 3.)

The percentages added for each shop are for department non-productive labour, and will be explained hereafter. The number 2,611 in the right top corner is the catalogue number of the article, borne in common by each card referring to it. All these cards are arranged by the cost-clerk in a drawer cabinet, the parts distinguished by tabs and the different kinds of articles by means of guide cards. Some firms duplicate the cards as they come in from the various departments, the copy being returned to the foreman of the department for reference.

Before proceeding further it may be as well to draw attention to the vast amount of fetching and carrying between the various departments and the office necessitated by a thorough organisation of this kind. Instead of the usual boys employed for the purpose, a more rapid, economical, and reliable method of inter-communication between the various departments is available: the *pneumatic tube system*. The card or sheet, enclosed in a suitable case, is dropped into the proper tube, and the mere pressure of a lever sends the packet like a flash to its destination. The initial outlay for the installation is not very high, and is soon refunded.

FIGURING OUT THE LABOUR.

Labour, the most difficult item in the factory to organise and manage, is a comparatively simple matter in the computation of costs. Labour is divided into three classes :—



METAL FRAME
8 × 20

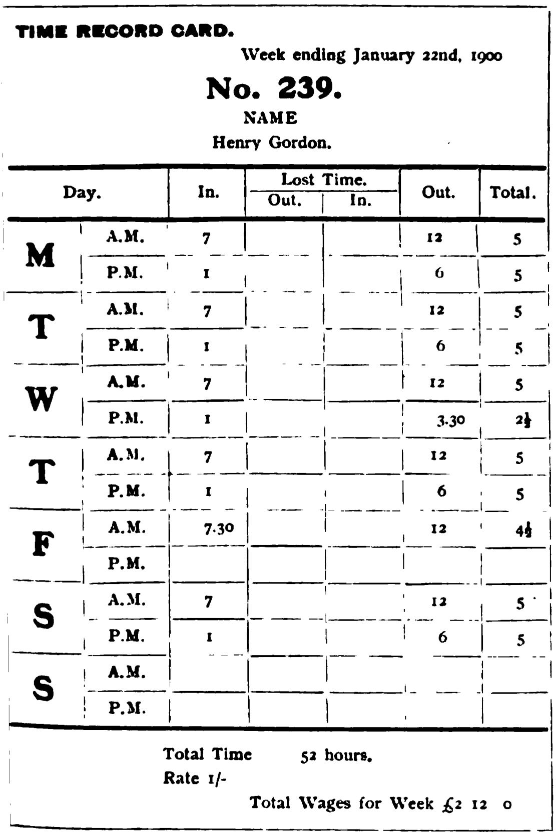
Crescent S. D. Rake
Prod. Labour Summary.

No. 2,611.
Oct. 20th, 1901

LABOUR SUMMARY.

	£ s. d.
Wood Shop	3 5 0
Paint Shop	1 12 0
Machine Shop	1 16 0
Steel Shop	2 10 0
Assembly Room	3 1 0
Foundry	2 9 0
Total	£14 13 0

FIG. 4. LABOUR SUMMARY CARD.



TIME RECORD CARD.
Week ending January 22nd, 1900
No. 239.
NAME
Henry Gordon.

Day.		In.	Lost Time.		Out.	Total.
			Out.	In.		
M	A.M.	7			12	5
	P.M.	1			6	5
T	A.M.	7			12	5
	P.M.	1			6	5
W	A.M.	7			12	5
	P.M.	1			3.30	2½
T	A.M.	7			12	5
	P.M.	1			6	5
F	A.M.	7.30			12	4½
	P.M.					
S	A.M.	7			12	5
	P.M.	1			6	5
S	A.M.					
	P.M.					

Total Time 52 hours.
Rate 1/-
Total Wages for Week £2 12 0

FIG. 5. WEEKLY TIME CARD.

(1) *Productive labour* is that which produces something of asset value, which, in fact, turns raw material into a finished product.

(2) *Departmental non-productive labour* is that which in every department is necessary for the carrying on of productive labour, but which does not of itself produce anything. To this class of labour belong the foreman, his clerk, the ostlers, sweepers, truckers, etc.

(3) *General non-productive labour* consists of the clerical staff, the engineers, draughtsmen, shipping and stores-clerks, belonging to no one department, but where labour is essential to the operation of the production departments.

In order to obtain the absolute labour cost of producing a piece or part, it is, therefore, necessary to take into consideration not only the flat labour, easily obtained from the Labour Summary Cards (fig. 4.), but also the departmental and general non-productive labour Herein lies what is usually considered the difficulty, but with the system of record-keeping here outlined, the calculation becomes simple: the amount of productive labour for the week is divided into that of departmental non-productive labour, the quotient gives the percentage of non-productive labour chargeable to any given productive labour. The percentage of general non-productive labour is determined

TIME CARD.

Dept. 1. Check No. 20.

Workman, John N. Wilson. Sept. 21st, 1900.

Sawing out .. .. 100 .... C 1.

Prod. · at 5/- 5/-

Hours......... 5. Foreman..................

Morning.				Afternoon.			
Start.		Stop.		Start.		Stop.	
6	10 20 30 40 50	6	10 20 30 40 50	12	10 20 30 40 50	12	10 20 30 40 50
7	10 20 30 40 50	7	10 20 30 40 50	1	10 20 30 40 50	1	10 20 30 40 50
8	10 20 30 40 50	8	10 20 30 40 50	2	10 20 30 40 50	2	10 20 30 40 50
9	10 20 30 40 50	9	10 20 30 40 50	3	10 20 30 40 50	3	10 20 30 40 50
10	10 20 30 40 50	10	10 20 30 40 50	4	10 20 30 40 50	4	10 20 30 40 50
11	10 20 0 40 50	11	10 20 30 40 50	5	10 20 30 40 50	5	10 20 30 40 50

FIG. 6.

LABOUR STATEMENT.

Wood Shop. Sept. 22nd, 1900.

Distribution.	Pro. piece.	Pro. day.	Non-pro.	Total.
	£ s. d.	£ s. d.	£ s. d.	
Pro. piece wks.	35 0 0			
Pro. day		2 10 0		
Non-pro. piece			0 7 0	
" " day			14 10 0	
Totals for week	£35 0 0	£2 10 0	£14 17 0	£52 7 0
Totals last week	£36 10 0	£3 1 0	£13 5 0	£52 16 0
Totals to date	£360 0 0	£54 1 0	£136 2 0	£550 3 0

Dept. non-pro. for week ....

" " for last week ....

" " to date..

FIG. 7.

LABOUR SUMMARY.

Week ending Sept. 22nd, 1900.

Depts.	Name.	Pro. piece.	Pro. day.	Non-pro.	Total.
		£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	Wood	35 0 0	2 10 0	15 0 0	52 10 0
2	Paint				
3	Machine ..				
4	Steel				
5	Assembly ..				
6	Foundry ..				
7	Shipping ..				
8	Miscellaneous				
	Total for week				
	" last "				
	" to date				

Grand non-pro. for week..................

" " last week..................

" " to date..................

FIG. 8.

in the same manner and added to the other two amounts, thus giving the total labour charges.

If £40, for example, be the value of productive labour in a certain department for the week, and £10 the departmental non-productive labour, the percentage chargeable for each piece or part is 25 per cent. of the productive labour. The general non-productive labour for the same week being £96, and the total productive labour £240, the percentage chargeable to each part is therefore 40 per cent. of the productive labour. This computation explains the percentages on the Assembled Costs Card (fig. 3), those for the departmental non-productive labour being written under the productive labour of each department, and the general non-productive chargeable on labour 40 per cent. on the lowest space, together with the percentage 3 per cent. for material. If these percentages be accurately computed, the total amount of productive labour, plus the percentage for non-productive labour, gives as a result the exact amount of the pay roll as issued by the time-keeper and the office, and checked by the cost-clerk.

It has been found that piece work gives the best results for men and master. Piece prices in all departments greatly simplify the records and make it possible to handle the cost of labour more satisfactorily, and to reduce the cost of manufacture.

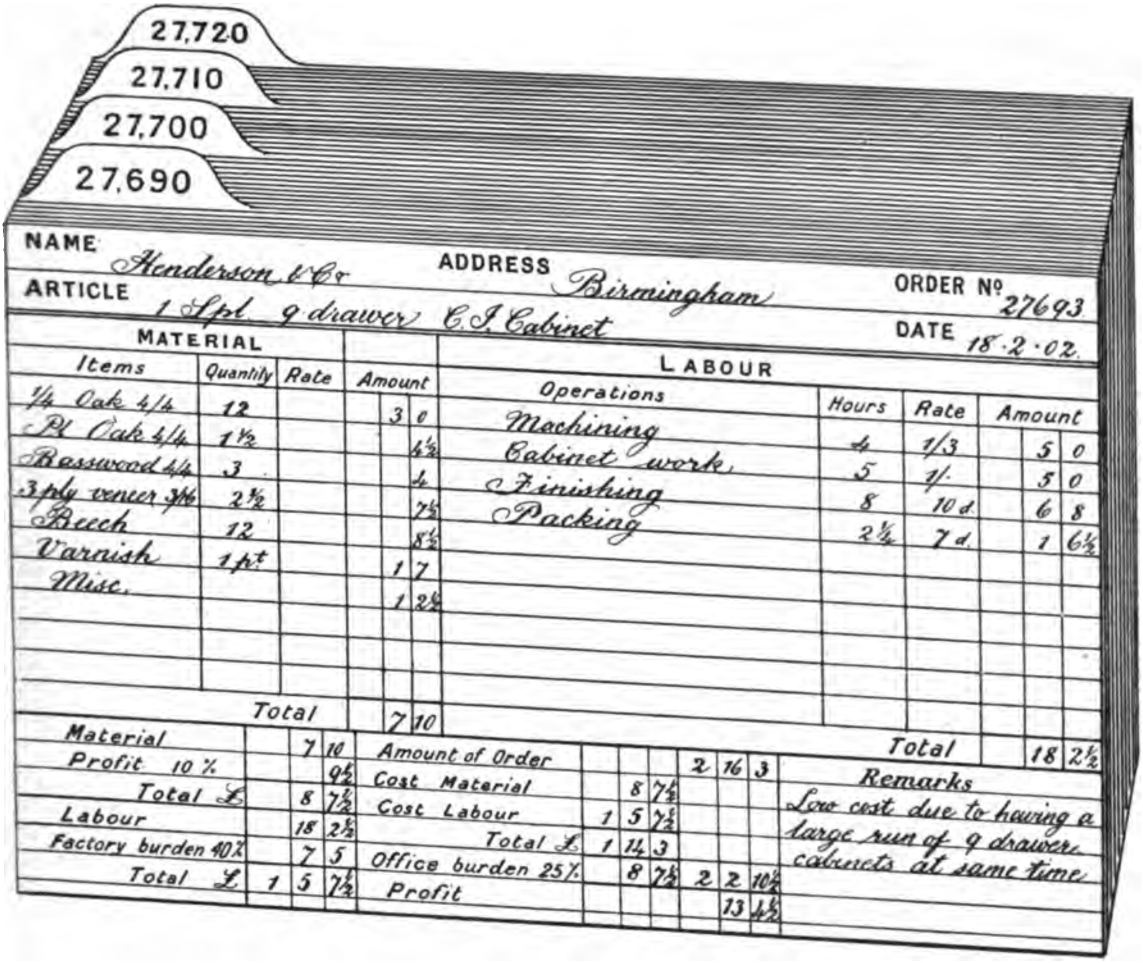
It is well to provide a small cabinet for each department in which record cards of the prices paid for all the work of the shop can be kept for ready reference.

The card bears the name of the part as heading, and the operations required of the shop are enumerated below. Six columns are provided to register changes in the piece price, so that each card lasts a long time, being ruled on both sides.

As many of these parts are common to several articles manufactured in the workshop, the same card suffices in making up the cost of all.

It is recommended that the piece-price cards for all departments be duplicated, and a copy of each kept by the time-keeper to assist him in making out the pay roll.

In shops where the workmen's jobs are run through in small lots, it is well to credit him with the number of prices made—at piece prices—and, if the amount falls short of his day


27,720
27,710
27,700
27,690

NAME *Henderson & Co*
ADDRESS *Birmingham*
ORDER No *27693*
ARTICLE *1 Spl 9 drawer C.I. Cabinet*
DATE *18.2.02.*

MATERIAL

Items	Quantity	Rate	Amount		
1/4 Oak 4/4	12			3	0
Pl Oak 4/4	1½				4½
Basswood 4/4	3				4
3 ply veneer 3/16	2½				7½
Beech	12				8½
Varnish	1 pt			1	7
Misc.				1	2½
Total				7	10

LABOUR

Operations	Hours	Rate	Amount		
Machining	4	1/3		5	0
Cabinet work	5	1/-		5	0
Finishing	8	10 d.		6	8
Packing	2¼	7 d.		1	6½
Total				18	2½

Material		7	10
Profit 10 %			9½
Total £		8	7½
Labour		18	2½
Factory burden 40%		7	5
Total £	1	5	7½

Amount of Order				2	16	3
Cost Material		8	7½			
Cost Labour	1	5	7½			
Total £	1	14	3			
Office burden 25%		8	7½	2	2	10½
Profit					13	4½

Remarks
Low cost due to having a large run of 9 drawer cabinets at same time.

FIG. 9. ASSEMBLED COSTS CARD.

wage, to allow him the balance, which is then charged as non-productive labour. Thus, the men will be more willing to work at piece prices if they know they will not be losers in any case, and may often earn considerably more.

TIME RECORDING.

The method of registering the workmen's time on entering and leaving the factory, by means of a time recording system, was referred to in a former article. This automatic recorder is equally invaluable in the workshops, instead of allowing the men to fill in their cards by hand. The card supplied is dropped into the slot by the workman on commencing his job, and again at the completion, when he signs his name or has the card punched by the foreman. At the end of the day there is a card from every operation, and the total number of hours on the several cards must correspond with the total amount of the time recorded on the weekly card. These cards are despatched through the pneumatic tube to the cost-keeper, who makes out a duplicate, which he forwards by the same means to the time-keeper, who day by day checks these by the Weekly Time Cards (fig. 5), and adds the price from the piece-cost card, or the workmen's hour rate.

Those who prefer the time-card system instead of an automatic recorder, may find fig. 6 suggestive. These cards are used by every man on the pay-roll.

The time-keeper computes the pay-roll from the time-cards of all departments, and adds the percentages for non-productive labour for the use of the cost-clerk.

Figures 7 and 8 show a departmental Weekly Labour Cost Card and a Weekly Labour Summary which explain themselves.

MANUFACTURING EXPENSE.

This comprises the cost of the supplies used in the factory, such as belting, emery cloth, buckets, brooms, stationery, fuel, oil, power, etc., etc.

At stocktaking time an inventory is taken of supplies on hand listed at their asset value, a percentage being deducted from the value for partly used articles. After the inventory has been made, the foreman of a department makes a requisition to the stores-keeper on a proper card for such supplies as he needs; this order received and filled, the supply is entered on a stock-card and charged by the cost-keeper to the proper department, and the stock-keeper has a card for each article and one for each department, and does his posting day by day. The latter card bears on a tab the department number, as heading the supply; and under, in columns, date, order number, quantity, price, cost and total. The cards are thus easily found in the drawer, and a weekly summary is made out from them as for other items.

In order to pro-rate manufacturing expense over the cost of production of an article, the whole output of the factory computed from the cost-cards is divided into the total cost of the supplies used. This gives the percentage which, added to material and labour costs, gives the net factory costs.

GENERAL EXPENSE.

The principal items of general expense are: Rent, taxes, salaries, travelling expenses, insurance, uncollectable debts, depreciation, telephones, postage expenses, advertisements, power, etc. The amount of these items forms a total which, divided by the total cost of the entire output, less the value of material on hand, gives the percentage to be added to the material, labour, and manufacturing expense. (See fig. 9.) The factory burden 40 per cent. includes manufacturing expense, and office burden includes general expenses and special debts.

SPECIAL COSTS.

These include extra items due to failure in delivery of an order for material to time, to defects in manufacture, etc., and may be charged when possible to the specific part of the product affected or pro-rated over the total cost of the product.

To those familiar with the card system numerous elaborations and modifications of this outline suitable to their own case will suggest themselves.

THE CRITICAL POSITION OF PIG-IRON.

BY

BENJAMIN TAYLOR.

In this article the author discusses the unprecedented condition of the iron trade and the probable effects of America's present insatiable appetite for pig-iron.

THE position of the manufactured iron and steel trades is now one of considerable perplexity, not to say anxiety. On the one hand, pig-iron is becoming more and more scarce and is gradually advancing in price. On the other hand, prices of finished material are dropping before the decline in general industries (especially in shipbuilding) and under the influence of German competition. We may put it that pig-iron is dear because America cannot produce enough of it for her own immediate needs, and that finished iron is cheap because Germany is still producing far more than she can consume. There is no precedent for the present position of the iron trade of the world, and the most experienced persons in it are unable to say what will be the immediate outcome.

More pig-iron is now being made than ever was made before, and a great deal more is being made in Europe than Europe can consume. But in the meantime the American appetite for it seems insatiable, and a condition of quasi-famine has been created, the term of endurance of which no one can foretell.

FLUCTUATIONS.

Three years ago we were on the verge of an iron famine, but from quite other causes. In 1897 and 1898 the industrial "new birth" in Germany caused such a run upon our reserves of iron that they were nearly exhausted, although the production was increased. In 1898 the American output was about 12,000,000 tons, and that left a considerable surplus for export, which rather relieved the tension. In the next year, however, America became a large buyer of British iron, the production of which seemed then to have reached its maximum, as there was no more ore readily available. In 1899 the American output reached 13½ million tons, but the American consumption was still larger. The output was increased in the next year to close upon 14 million tons, and in that year Germany, Holland, and Belgium drew nearly a million tons from us. The total exports of pig-iron in 1900 reached 1,427,525 tons; and the total stocks in all the public stores were reduced at one time to 126,000 tons—a startling contrast to the 1,245,000 tons stocked in the Glasgow stores alone a few years previous. In 1900, however, we received 100,000 tons from the United States, and it was thought that there would never be another pig-iron famine, as the American output was more than sufficient to supply the needs of the whole world. Then came the industrial boom in America last year, accompanied by an increase to 15,870,000 tons in the production of pig-iron. This was concurrent with the collapse in Germany, who in that year (along with Holland and Belgium) took from us only 387,600 tons; whilst, at the same time, our entire exports dropped to 839,223 tons. On the other hand, our imports of pig-iron increased from 175,393 tons; for although we received 60,000 tons less from the United States, Canada was now in the market as a purveyor, and sent us some 50,000 tons from the Cape Breton furnaces. Moreover, Germany had to realise on her heavy stocks, and sent us some cheap parcels of basic-iron.

Last year was an anomalous one as regards pig-iron. There was a general, though not universal, decline in production, consumption, exports and stocks. The production of the United Kingdom was reduced by about a million tons, and the home consumption by about 750,000 tons. The striking features of the year were the great decrease in the German demand, the cessation of imports from America, and the receipt of supplies for the first time from Nova Scotia. Another rather striking feature was an increase of 2,000,000 tons in American production, and the absorption in America of practically the whole of it by their home markets. This year, the outstanding feature has been the enormous advance in American consumption, greater even than the increase in production.

RESULTS OF THE AMERICAN BOOM.

Within two years America has changed from being our largest prospective competitor and potential purveyor to being our largest customer. In the eight months ending August 31st, the exports to Germany, Holland, and Belgium were only 152,207 tons, or 133,264 tons less than in the corresponding portion of 1901. But in the same eight months our exports to the United States were 211,317 tons, or 183,360 tons more than in the corresponding portion of last year. America, therefore, has taken the place of Germany as our largest customer, and has even purchased 50,000 tons more. The shipments of the last quarter of the year will bring out a still more striking increase, for numerous large orders have been received since the end of August. And besides this increase in the exports to the United States there was an increase of 17,000 tons in the exports to Canada, due to the fact that the American smelters were unable to supply their Canadian consumers. In the eight months, then, America has taken from us 200,000 tons more pig-iron than during last year, while Germany has taken 133,364 tons less. In addition, America has received large consignments from Germany, and this has caused a further dearth in the home markets.

A curious feature about these German shipments to the United States is that they include some parcels of British iron purchased in 1899 and 1900, which have remained in stock in Germany ever since.

The actual amount of the German shipments to the United States is not yet known. In the seven months ending July, 1902, the imports of pig-iron into the United States were 177,763 tons, of which 141,345 tons were received from Great Britain. This left a balance of 36,400 tons to be derived from Germany and other quarters, including Nova Scotia. But since the end of July the movement has been much more active; and it would probably not be too much to assume that by the end of September the United States had imported 50,000 tons of pig-iron from Germany, besides what was taken from Great Britain and Canada. The following were the imports of iron and steel to America in the seven months ending July, which are the latest figures available at the time of writing:—

IMPORTS INTO UNITED STATES DURING THE SEVEN MONTHS, ENDING JULY, 1902.

	1901. Tons.	1902. Tons.
Pig-iron	23,930	177,763
Scrap iron and steel ...	8,557	48,650
Bar iron	10,070	12,391
Railway iron	853	21,475
Hoops	457	2,739
Steel ingots and billets ...	4,489	113,264
Sheets and plates ...	2,191	3,891
Tin plates...	33,690	39,669
Wire rods...	9,858	11,107
Wire	2,106	2,084
Total ...	96,251	433,033

A STILL GROWING DEMAND.

These figures, however, only reveal the beginning of the movement. More than one-third of the total imports of the seven months were in July, In August they were larger and in September larger still. The following shows the fluctuation of the pig-iron trade between the United States and the United Kingdom during the eight months ending August, 1902:—

	Exports from U.K. to U.S. Tons.	Imports from U.S. to U.K. Tons.
Jan.-Aug., 1901 ...	27,957 ...	28,387
Jan.-Aug., 1902 ...	211,317 ...	8,894

This very strikingly illustrates the change in the position as far as America is concerned.

It is also interesting to compare the total exports and imports of pig-iron.

EXPORTS FROM AND IMPORTS TO THE UNITED KINGDOM.

	Exports. Tons.	Imports. Tons.
Jan.-Aug., 1901	583,087	99,757
Jan.-Aug., 1902	612,930	165,264

The imports were thus divided :—

IMPORTS OF PIG-IRON INTO THE UNITED KINGDOM—EIGHT MONTHS ENDING AUGUST.

From	Jan.-Aug. 1901. Tons.	Jan.-Aug. 1902. Tons.
Sweden	42,897	38,193
United States	28,387	8,894
Other Countries	28,473	118,177
Total	99,757	165,264

It seems absurd that nearly three-fourths of the quantity should be described as being from "other countries"; and it is to be hoped that in future the returns will be recorded so as to show the sources of supply. In the imports from "other countries" there is always a small quantity from Spain, but in the periods embraced in the above table the total was swollen by imports from Germany, from South Russia, and (especially) from Nova Scotia. The undoubtedly phenomenal imports from Germany and Russia are of only a temporary nature, and are simply due to excessive over-production in these countries, in consequence of which large quantities of accumulated stock have to be disposed of at a loss.

The imports from Nova Scotia, however, are expressive of a new development of the industry, and what is probably destined to be a permanent source of trade. At present the United States has secured the output of the Nova Scotia furnaces, and not much is being shipped to this country. But when Uncle Sam's wants are satisfied, Canadian iron will again be sent here in larger quantities.

Taking the whole year, the exports and imports of pig-iron for the previous three years were :—

Year.	Exports. Tons.	Imports. Tons.
1899	1,380,342	171,373
1900	1,427,525	175,393
1901	839,223	195,409

Therefore, during the first eight months of the present year our imports were only 10,000 tons less than the whole quantity imported in all 1900, and only 30,000 tons less than the whole quantity imported last year. It will also be seen that during the last eight months we exported 34,843 tons and imported 65,507 tons more than last year. The increase in imports being nearly double that of exports, there should have been an ample supply for home consumption had other things been equal. But other things were not equal. The output has been smaller, and since January 1st the stocks in the public stores of Scotland, Cleveland and Cumberland have been reduced by about 20,000 tons. America has not only been drawing pig-iron from us, but also finished iron, steel ingots, and structural shapes. Again, the inability of American producers to execute foreign orders has diverted some of these orders to us. In the first six months of this year the exports of iron and steel from the United States dropped 50 per cent., and they have receded still further since. Our own exports of all iron and steel (including pig-iron), in the eight months ending August, increased from 1,941,739 tons to 2,239,300 tons. This, then, is where all the pig-iron has gone—to supply not only the needs of American manufacturers, but also the needs of the American consumers.

AMERICAN MANUFACTURERS RELY UPON GREAT BRITAIN AND GERMANY.

And yet the production of pig-iron in the United States has gone on increasing, notwithstanding the strike of the anthracite miners. That strike affected the output of foundry iron in the Eastern States, and it was for foundry iron that American buyers first came to Glasgow and Middlesbrough. It is evident, however, that the steel manufacturers of America have "bitten off more than they can chew." The demand for structural material in connection with huge "sky-scrapers" in the big cities, and for railroads and bridges, shipyards, etc., has proved beyond their capacity, and at all events beyond their capacity to supply from native raw material. Thus they have had to fall back on British and German manufacturers for their supplies of iron, steel ingots, slabs, plates, and (latterly) rails.

It was reported recently that an American shipbuilding company had contracted for the supply of 80,000 tons of steel ship plates for a Scotch company. Although the report was lacking in authenticity, it is certainly remarkable that Americans should now even talk of building ships in their yards with foreign plates, when two years ago they were threatening to supply the world with shipbuilding steel.

The same position is also observable with regard to rails. The United States Steel Corporation was credited with ability to make railway material for all Europe as well as America; yet American railway companies are buying steel rails in England and Germany.

Despite the serious difficulties in connection with the supply of anthracite coal and coke—due very often to delays in transit—this year's production of pig-iron in America is larger than ever. In the first six months of 1902 the actual output was 8,808,574 tons, or equal say to 17,620,000 tons for the whole year. Since then the output has been raised to about 1,500,000 tons per month, and it is estimated that by the end of the year a total of 18,000,000 tons will have been turned out.

OUTPUT OF PIG-IRON IN THE UNITED STATES.

Year.	Tons.	Year.	Tons.
1897 ...	9,652,680	1900 ...	13,789,242
1898 ...	11,773,934	1901 ...	15,878,354
1899 ...	13,620,703	1902 (est.)	18,000,000

Nor does 18 million tons represent the full limit of the producing capacity of the existing plant; for a monthly output of 1,500,000 tons was made in September with only 272 out of 336 furnaces in blast. Were the whole number utilised the output might reach 20,000,000 tons. But is is impossible to light all the furnaces because they are not all fit for use. The supply of ore is no more than feeds the furnaces already blowing, and the resources of the coke-makers and the railways are taxed to the utmost in providing the fuel. When the strike of the miners is over there will be a freer supply of hard coal, but the effect on the output of pig-iron will not be so great as may be supposed, although, no doubt, it will be important. But without speculating on the possible or probable increase, the plain fact is that an output of 18,000,000 tons will be some 1,000,000 tons short of America's actual and prospective consuming requirements for this year.

This large quantity the Americans are taking in the form both of crude and finished material. And in so taking it they have reduced our own reserves to only about the equivalent of one week's consumption of the United Kingdom. Not only is this so; but perhaps three-fourths of our reserves are now held by warrants on account of American manufacturers. Should the pressure be accentuated on the other side the warrant stores may be swept away in a week or two. In this case the smelters of England and Scotland would have no reserves, as they are delivering to home consumers and shippers almost as fast as they can turn out the material.

THE PRESENT POSITION.

In America the position seems to be that they do not care what crude iron costs so long as they get it. They must have it in order that manufacturers may fulfil their contracts. A Philadelphia correspondent recently reported that there is now less anxiety among consumers about the ability of American furnaces to meet their requirements in the near future, as they have found good substitutes in Scottish and English iron, the quality of which has given great satisfaction, and which can be promptly supplied as required.

It is clear from this and other indications that America is relying upon us to pull her through her present difficulties caused by the excessive and perhaps speculative development in building enterprises. The *Iron Age* of New York is right in saying that the American market has been the salvation of the British and German markets this year. But may it not also prove their ruin? "Ocean freights," says this well-informed journal, "are lower than they have been for years, and our enormous crops will divert tonnage to our leading ports for months to come, so that freights will be very little more from European ports than from our own mills and furnaces. The one dominating feature for the future, therefore, will be large supplies of foreign material for months to come at prices not higher than those of to-day; and in case the home production increases there may be recessions more or less important, as a result of the competition, which cannot be avoided, although it may be months before it becomes serious."

Who can say how many months? Before the turn comes we may have pig-iron at famine prices; but when once the consumption slackens in America there will be an appalling surplus there to crush the world's markets.

COMBINATION AND COMPETITION.

BY

CHARLES LANCASTER.

AT a time when everyone engaged in British manufacturing enterprise is compelled, *nolens volens*, to face an unprecedented severity of competition, it may not be out of place to pass in review some of the arguments urged in favour of the modern "Trust," and to consider how far such a combination is justified by the Companies' Act of 1862. Before that date the right to trade, except as partners, was denied, and the issuing of transferable stock without special legal authority was a punishable offence. The few companies whose operations were so specially authorised by Parliament were, therefore, monopolies, and it was intended that they should be monopolies, giving exclusive control of industries without competition within the sphere of the granted rights.

WHAT IS A "TRUST"?

A good deal of discussion has been wasted on the word "Trust." The term is a misnomer; but, having been popularly accepted, its loose and indiscriminate use requires explanation. The great exemplar of a *bonâ-fide* Trust was the Standard Oil Trust. Here a large number of refineries, called corporations, placed their stock, with its voting power, in the hands of trustees; and thus, while enjoying a separate legal existence, each refinery was subject to a single, central control. But the wisdom of American legislators decided that this form of Trust was a combination which might lead to restraint of trade. Therefore, all such combinations have been abandoned, and are replaced by great single companies or corporations, of which the Standard Oil Company and the United States Steel Corporation are the greatest examples.

There were never at any time more than four or five real trusts; now there are none. The name, however, survives, and will probably remain, because the directors of these vast concerns are undoubtedly, in the highest sense, trustees of the money of large numbers of stockholders. They are also trustees having collective responsibilities with regard to hundreds of thousands of employees—heavy burdens that never rested upon the smaller concerns whose businesses have been taken over. Mr. Archbold, one of the heads of the Standard Oil Company, has given a definition of the word "Trust," which has frequently been quoted as a model of perspicuity. "Trusts," says Mr. Archbold, "are large aggregations of capital for the purpose of carrying on industries. How large the aggregation must be to constitute a Trust, no one knows, nor is it material, since the effects of aggregation of capital are the same, be the amount small or large."

The encouragement of trade rests upon freedom to combine and freedom to compete. The logical conclusion of such an alliance is that competition is moved to a higher plane by seeking to increase manufacturing profits through an enlarged volume of transactions, so that a small profit shall yield greater returns on a large volume of business than a large profit on a small volume of business.

ITS GROWTH IN THE UNITED STATES.

In the United States, where the prevailing tendency has always been to individual freedom of action, the "Trust" has found congenial soil. No doubt, in the early, unenlightened and non-progressive days, many petty restrictions were practised, but Government interference never reached the limits laid down in England. On the contrary, the development of the natural industries of America was fostered by the wholesale tariff legislation which has achieved such remarkable results. The phenomenal and quite unparalleled success of the Standard Oil Company, formed in 1873, naturally originated hostility. When has success not had this result? The men whose genius foresaw the future of the great petroleum industry, and whose indomitable energy and daring carried them to success, despite the furious opposition of their enemies—whose name was legion—deserve more than the fortunes they have made. They have, in the best sense, been benefactors of mankind. They found a valuable natural product, which was first discovered in America only in 1859, and instantly devoted themselves to exploit its uses. Every one of the most important processes which gave the world the best illuminating oil, and the numerous and beautiful results of treating the bye-products, was discovered by these men and their allies.

AMERICA'S PROTECTIVE TARIFF.

It is a favourite argument of a good many of our countrymen that the success of these modern enterprises in America depends entirely upon the protective American tariff. No one will deny that this has been, and still is, partially true. The original intention of the founders of the American tariff—statesmen, like Hamilton and others—was to give manufacturing industries a chance to start. In short, it was proposed to restrict its operations to such manufactures as were not already established, and that it should be modified where possible. For good or for evil, the McKinley Act of 1890 adopted a very different line to that advocated by the great economic school which Hamilton practically founded. Exactly one hundred years before the passing of the McKinley Act of 1890, Hamilton considered the iron and steel industry established in America, although he agreed that temporary duties of 7½ to 10 per cent. might be imposed.

Twenty-five years ago, the world's output of pig-iron was 14½ million tons per annum. Since then the amount produced has nearly trebled, the total annual output being about 42 million tons. America has led the way in this increase, and she is to-day producing more than the whole world produced a quarter of a century ago. From 1870 to 1880 the output of steel rails in America was under 3½ million tons. During the next ten years she manufactured 14½ million tons, and in the last decade of the century nearly 16 million tons. During the thirty-five years which have elapsed since 1867, when America first engaged in the manufacture of steel rails, she has produced nearly 34 million tons, of which nearly half were made in the last ten years of the nineteenth century. She is now producing nearly 3 million tons annually. A high duty on imported steel rails has largely contributed towards the prosperity of the industry. For the first thirteen years the duty was 28 dols. per ton; but this was reduced to 27 dols., again to 13½ dols., and finally to 7·84 dols. in 1894, where it still remains. Notwithstanding the practical monopoly secured by this high protective tariff, however, the prices charged to American customers for steel rails did not average more than £5 12s. per ton, and in 1898 the price fell to £3 10s. per ton, a figure much less than the average duty charged from 1867 to 1882. Indeed, of late years, the prices of steel rails in America have been nearly the same as in England. Had the duties in force for twenty years past on imported rails been paid by Americans, in the absence of domestic manufacture, they would have amounted (plus ocean freight charges) to nearly 700 million dols., or over 20 dols. per ton. Instead of which, the price fell in 1898 to 17½ dols. per ton, or £3 10s. In this case, the formation of large aggregations of capital has clearly been of great benefit to the consumer.

THE AMERICAN ATTITUDE.

Let us for a moment consider the view of a typical, enthusiastic and progressive American.

We can imagine him saying: "The prices American consumers pay for things are not in reality large, but moderate in comparison with prices asked in other countries. The strength of the manufacturer's business lies in the enormous consumption, and in the fact that he works his factory as nearly as possible to the limit. A factory working at only 60 per cent. of its capacity makes the cost of the articles produced very high; but, if the same factory can be run at 90 or even 100 per cent. of its capacity, the articles cost much less to produce. In fact, the manufacturer is enabled to sell his goods at the cost price of articles produced by factories working at 60 per cent. capacity, and, at the same time, secure a handsome profit. Moreover, it is a fact that the articles sold at cost abroad serve to keep the American factory running at full capacity, and therefore keep the workmen employed all the time. The above explanation is the secret of Transatlantic combinations. If a firm has a factory representing a capital of 100,000 dols., capital investment, paying the handsome return of 21 per cent., and a promoter comes along and offers 300,000 dols. for the plant, the firm seizes the opportunity to sell. The promoter, however, proceeds to buy two other plants, all, let us say, of the same value and the same earning capacity, at an expense of 900,000 dols., and appears to have an expensive investment in his hands. He knows, however, that the three factories probably run about 60 per cent. capacity, and if he reduces them to two factories running 100 per cent. capacity, he will increase the net earnings from 63,000 dols. a year to 80,000 or 90,000 dols. a year. Therefore he forms a Trust, or combination company of, say, 2,000,000 dols., of which 1,000,000 dols. are preference shares at 7 per cent. interest, and 1,000,000 are common shares of uncertain interest. The comparison between 300,000 dols. in intrinsic value and 2,000,000 dols. nominal value seems extraordinary, but experience has shown, owing to the wonderful growth of the country, and the very remarkable economies that are obtained by combination of like industries, that the inflated nominal price, while discounting the future, has rapidly grown up to intrinsic value—the 7 per cent. preference shares going to a premium, and the ordinary shares, floated generally at 25 dols., going up to 60 dols. or more. The enormous amount of money floating and demanding an investment takes up these shares, and the inflated combination holds over its period of trial, and, after a time, becomes solidified, and actually grows in intrinsic value to 1,500,000 dols. or 2,000,000 dols.

"The greater combinations are generally spread until so many thousands of people are interested that no ordinary attack or business reverse can affect the conglomerate whole. This is the position of the United States Steel Corporation. It has so many shares, and there are such an enormous number of people interested (not only the shareholders, but the office holders and employees) that it gathers strength with its very bigness. It is entrenched in its position, and has only to hold itself together to get bigger and sounder, to reduce prices, and to control the world in its line of manufacture. It is the nearest actual approach to Socialism on a common-sense practical basis that the world has yet come to. I do not think there is any danger to the community in such a vast aggregation, as no man is big enough to wield its enormous power alone for evil, nor can even a set of men do so by conspiring together. It seems to me a form of lasting institution held permanent by the interest of men, for its influence permeates all classes."

TRUSTS AND COMPETITION.

What reason have we to share the view here set forth? It is difficult, perhaps, to see all at once that combination does not destroy competition—but rather stimulates it. The problem, as it strikes the American mind, appears to be that great businesses are built up by making goods as cheaply and well as possible, and by never losing sight of the fact that, having created the business by these means, the next thing to do is to keep it, by sedulously practising the same economies of production in the effort to still further widen the market. To raise the price would be to create a boom and ruin the business.

Business, then, is better than boom. Competition must exist under all circumstances, and the greatest struggles will be between the giant companies, which are the centres of enormous wealth and power, and of the greatest mechanical skill. The popular impression about Trusts in England has far too often been that they are business Juggernauts, crushing all competition before them. Especially has this been urged against the pioneer of Trusts, the Standard Oil Combination. This great concern has never been free from competition; and the malice evinced against it for many years arose principally because it could make and sell petroleum more cheaply than its rivals. Indeed, the amazing improvements effected in the refinement of crude petroleum have largely come about in consequence of the vigorous and unceasing competition of others.

Combinations, or "Trusts," call them what you will, depend upon the prudent management of their affairs for their very existence. Directly anything in the shape of monopoly or restraint of free trading is started, so soon will the very existence of the combination be threatened. The American plan is not so much to seek the highest price for their goods as to lessen the cost of production, and to fix the lowest percentage of profit upon the largest volume of transactions. To cite only a few instances, it is thus that America has increased her export of blue vitriol from 4,000 tons five years ago to over 20,000 tons. Five years ago Great Britain exported 90 per cent. of all the blue vitriol sent to the Continent. America now makes this more cheaply, and has taken over half this trade from us. Copper from Australia and Japan comes to Liverpool, and from thence is shipped to America, where it is refined, and then sent back to England. The supremacy of this country as a copper centre is gone.

It is a significant fact that the United States Steel Corporation has taken contracts to erect large works for other combinations which oppose and compete with the great Steel Trust itself. There cannot be any reason to look for monopoly here, if one combination is ready to assist a competitor to start by erecting his buildings for him. The production of the Steel Corporation last year (1901), compared with the total production of the whole of the U.S.A., appears to be : Of pig-iron, 43·9 per cent.; of Bessemer, and open-hearth steel ingots and castings, 66·3 per cent.; and of all rolled products, 50 per cent.; which figures show that the Steel Corporation buys large quantities of pig iron from their rivals, as their manufactured output is not provided for by their own production of iron ore or pig iron. As a matter of fact, there is a steady increase of competition with the existing industrial combinations; and, since the "Billion Dollar Trust" was launched, many new companies have been started, with a capital estimated at nearly 150,000,000 dols., raised within a few months. Over a dozen have been incorporated in New Jersey this year. The wealth gained in America is continually re-invested, whereas the wealth gained in this country is too often spent in luxurious retirement from active business. With her unrivalled mineral wealth, America has presented many new openings for the re-investment of rapidly-acquired wealth, and she will present many more in the future. Meanwhile, she has the surprising advantage of being able to ask every other country in the world the question asked by Mr. Carnegie in a recent article—"Can any other country than the United States produce three pounds of steel for two cents?"

Combination does not kill competition—it stimulates it. In this imperfect world, competition will take upon itself several aspects, some unreasonable, to the extent of their being "cut-throat," and thus leading to waste and loss. In the latter sense, therefore, competition cannot be said to be the life of trade. There are many shibboleths in the market place, and this is one of them. Without doubt, undue competition in trade has caused individual distress. So, also—but to a much greater extent—has the want of competition. Combination and reasonable competition will not, and must not, assume exclusive privileges, whether the purpose and effect of combination is to corner every article necessary to the public, or limit production and thereby enhance prices. Up to the present, very large assumptions respecting the disastrous character of "Trusts" have brought upon them more of denunciation than reasonable inquiry into their scope and usefulness. Discrimination must be used, even as between trusts and trusts.

THE TRUSTS AND THE TARIFF.

The great question of the American tariff and the American Trusts will probably be raised, in due time, by the introduction of measures calculated to allow reasonable manufacturing profit on reasonable capital. Tariff revision may also arise from the necessity for Americans to take notice of the retaliatory action of the European Governments. It will be found necessary, as a common-sense procedure, that Americans should retain their foreign markets; and if the tariff is solely to preserve these outlets, public and political interest will in time assert itself. The Industrial Commission, which sat so long in America, was composed for the most part of warm protectionists; and the investigations of this body have undoubtedly cleared the air with reference to the nature of the projects which have for long governed all party utterances in the States. In short, the views of the Industrial Commissioners may be said to be fairly reflected in the general tone running throughout this article. The outcome so far of the proceedings of the Commission has plainly been to induce a feeling in the minds of the Commissioners—bearing in mind the enormous economies in manufacture originated by the "Trusts" and by the general excellence of their business arrangements (which are always entrusted to the care of recognised experts)—that the "Trusts" could still continue to do business even if the tariff were reduced, but on more moderate capital. On the other hand, the present high tariff is to some extent required as a protection for the smaller undertaking, which cannot pretend to compete with the more economical methods of the "Trusts." It must not be forgotten, however, that not only are American goods sold at lower prices to foreign markets, but also that they are sold at varying prices in different parts of America. Goods manufactured in New York State, for instance, are proved to have been sold at much lower prices when sent to Chicago than they are sold at home. The price of the same goods is lower still when they are sent to Denver, and still more reduced when they reach Utah. It is necessary to fix these low prices, because of the incidence of the increased railroad rate and the lower cost of delivery by the local manufacturers. It is, in effect, the principle on which sales at lower prices to foreign countries are made.

HOSTILITY TO THE TRUSTS.

The extent of popular hostility to the Trusts has yet to be ascertained. It will probably be found that no actual hostility exists to these modern combinations, in view of the economies in manufacture and consequent lowering of prices which invariably result. Up to the present, all the Anti-Trust legislation in America—and there has been a good deal of it, extending over many years—has practically proved futile. In past years there has been great opposition to railway consolidations in America, and these combines have been fought over and over again most strenuously. But the system has gone on, and nothing particular has happened, except that bankrupt lines have frequently been reorganised.

Public feeling, however strongly expressed in America, has never seriously interfered with the developments of the great modern railroad organisations. Had the American public at any time just cause to be less satisfied than they are now, because of their loud-tongued opposition? It would be hard to say this was the case. May we not also ask the reasonable question whether, if similar results follow to the customers and employees of, say, the United States Steel Corporation, will merely academic objections long retain their force? One thing of which there is not the slightest doubt, is, that the Anti-Trust feeling throughout the vast extent of America to-day is trifling compared with that which existed fifteen or twenty years ago, though the more recent instances are on a much more widely extended scale.

Concerning the principle of combination or trusts—call it what we may—this was plainly indicated as the evolution of a natural law by writers like John Stuart Mill, many years ago.* In the imperfect state of our human nature the interests of the enormous forces recently created may appear to be increasing in greater proportion than the forces which make for perfect equal justice and public good but, on the other hand, it is a far cry to the millennium. In our country the acute problem appears to be not so much to organise Trusts, as to lighten the heavy burdens which manufacturing industries have to bear.

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* See "Political Economy," Vol. I., Chap. 9. Production on a large and on a small scale.

LOCOMOTIVE ENGINEERING NOTES.

Silly-season Records.

IGNORING, as neither scientific nor accurate, the romantic fictions about locomotive performances which have lately decorated the columns of the non-technical press, it is, nevertheless, a fact that some very fine locomotive work has been done recently, both in Britain and in France. As for the so-called "records," which have been published with such prodigal liberality, some are self-evidently impossible and absurd. Others are either ancient history or fall far short of feats accomplished seven, or fourteen, or twenty, or twenty-five or more years ago, which were well-known to every educated person, although, apparently, not to the "record-fakers." In most cases a diverting innocence of all acquaintance with the nature and possibilities of locomotive work is unconsciously displayed by the various writers.

Long-distance Records.

Those non-stopping runs made by the Great Western and London and North-Western respectively, while very interesting and creditable, did not in either case constitute a "record" in respect of distances run without stop, or of the speed at which they were run. The King's Great Western special, from Plymouth to Paddington, which covered the whole length of 264¾ miles without any intermediate halt, and the Irish Viceroy's London and North-Western special, which ran from Euston to Holyhead, 264 miles, stopping at no point midway, both fell far short of the existing British non-stopping long-distance record of 299¼ miles, and still farther short of the American record, which was achieved twenty-six years ago on two successive days, viz., 438½ miles. In the British case the run was on the London and North-Western, from Euston to Carlisle, and it was made in 1895. The American run was from Jersey City to Pittsburg and *vice versa*, and that took place no less than twenty-six years ago, viz., in the year 1876, when on the Pennsylvanian line a special train was run that whole distance of 438½ miles, without the wheels once ceasing to revolve, in 10 hours 5 minutes. This undoubtedly remains the long-distance non-stopping record for the whole world, and its performance is absolutely vouched for by the authorities of that railway. Nor is it at all likely to be soon eclipsed.

Difficulties of Long-distance Non-stopping Runs.

The difficulties which exist in the way of running these long distances without a halt, apart from that very troublesome problem of keeping a clear road throughout, may be summed up as consisting in (1) lubrication, (2) keeping a clear fire, (3) water supply, and (4) conveyance of sufficient fuel. Of these the first three have been in some degree overcome by the adoption of various modern appliances. Lubrication has not been found at all difficult. The fire trouble has been so far surmounted as to enable the runs to be made. Water is easily obtained while moving, by means of the track-troughs and pick-up scoops. But the carriage of fuel for such long distances does constitute a very formidable obstacle to long-distance runs. It was managed on the London and North-Western by dint of very careful packing on the tender, and on the Pennsylvania line by taking a large supply in the baggage-cars adjoining the tender, to which special means of access were provided.

Spectacular but "Not Business."

But while such performances are, no doubt, interesting, it may be questioned whether they are of much practical value save in their spectacular and purely advertising aspect. There may be competitive cases in which an advantage would accrue through making such runs. As a general rule, however, they are neither expedient nor even expeditious. For neither a locomotive nor its crew can possibly maintain freshness or keep in best "form" when subjected to so long-protracted a strain. It will be observed that it has never been deemed advisable to make these extremely long non-stopping runs at the highest speeds. In the cases of the Royal and Viceregal specials and of the Euston-Carlisle British record distance run, the average rate was only slightly over 50 miles an hour. This contrasts strongly with the daily work of many trains that run shorter distances without stop. The difference was particularly noticeable in the case of the Euston-Carlisle run, which only averaged about 51 miles an hour; whereas the same distance had been covered on the same line only two or 65 miles an hour, with an intermediate stop three weeks previously at an average rate of at Crewe to change engines. The truth is that a fresh engine, a fresh fire, and a fresh driver and fireman are very desirable every two hours or so on a long-distance journey, and it is doubtful whether the game be worth the candle when exceptionally long distances are allotted to one engine without change.

Locomotive Speed-Records.

It was not to be supposed that the glorious company of "record-fakers" would fail to provide a few spuriosities also in respect of fabulous speeds. But it must be admitted that this "silly season" they have attained to singularly exalted heights of absurdity. They have drawn with a light heart on several different countries· America is credited with an entire journey performed at the average rate of "130 miles an hour!" In the light of this latest "banger," the authors of the old oft-demolished, yet oft-revived, 112·5 miles an hour romance may well hide their diminished heads. The French story which has gone the round of all the papers is somewhat peculiar. The Boulogne-Paris express, on the Northern Railway of France, is alleged to have started 46 minutes late and reached Paris punctually, the distance being given as "139 miles" and the average speed as "68 miles an hour." As the true distance is 158 English miles, all but a small fraction, and the time allowed is 2 hours 50 minutes, which includes a midway stop of 5 minutes at Abbeville for water, it will easily be seen that the average speed, had 46 minutes really been gained on this booked running time of 2 hours 45 minutes, must have been not "68" but over 79 miles an hour; moreover as three banks respectively for 4 miles at 1 in 135, for 26 miles at 1 in 250 and 1 in 333, and 13 miles at 1 in 200 have to be climbed, while speed has to be reduced to walking pace through Amiens station and some way beyond, the speed down hill and on the level must have been 100 miles an hour or more had the reported feat been really accomplished. It is true that Monsieur du Bousquet's splendid "Atlantic" type de Glehn compounds have been tested at a speed of 145·2 kilomètres, or 90·3 miles an hour, but the speed of the regular trains is strictly limited by law to 74·6 miles an hour on the French Northern Railway; therefore it was distinctly unlikely that over 79 was *averaged* up and down hill, and including two startings and stoppings, various slowings, and the ascent of three banks. Since the above was written, it has been ascertained that the time made up was *sixteen* minutes, not "forty-six," thus the average speed was about 63 miles an hour which is assuredly not a "record" on the French Northern Railway.

The Midland Compound.

The British record set up (in print) had reference to a performance by Mr. S. W. Johnson's very fine new three-cylinder compound, No. 2631, on the Midland Railway, which was alleged not only to have made the journey of 76¾ miles from Hellifield to Carlisle in 79 minutes, start to stop, but also to have averaged 76·9 miles an hour over a considerable portion of the distance. Investigation, however, soon elicited that the average over that "76·9 miles an hour" length was exactly 70, and also that the 79 minutes run from Hellifield to Carlisle, while undoubtedly accomplished and a very excellent achievement, was not the "record" for that stage, the same journey of 76¾ miles having been done some weeks previously in five minutes less time, viz., in 74 minutes. Similarly it may be added, the alleged "record" run without stop from Euston to Holyhead had been several times done by the first portion of the Irish night mail when that was run in duplicate.

Two Million Miles by one Engine.

Speaking in the name of his famous London and North-Western locomotive, "Charles Dickens," No. 955, Mr. F. W. Webb has issued an interesting account of that efficient little engine's remarkable career. Built in 1882, she has in the course of her twenty years' life covered the amazing distance of 2,000,000 miles, having run daily from Manchester to Euston and back throughout the whole of that period, except when in for repairs. Two "crews" have worked the engine on alternate days, one of the drivers, Bowden, having been the same during the entire career of the locomotive. It is noteworthy that when the morning up express from Manchester to Euston was accelerated on June 1st last to make the journey— *viâ* the North Staffordshire route through the Potteries as far as Colwich—in 3 hours 50 minutes, "Charles Dickens" still hauled the train and did it in admirable style and time. It is considered, however, that a more powerful engine is now needed owing to the increased weight of the accelerated train, and so No. 955 is relegated to easier duties, and one of Mr. Webb's newest compounds takes her place. If the newcomer can in twenty years' time show relatively so fine a record as "Charles Dickens," it will be something of which worthily to boast. It may be worth while to note that every engine of the same class as "Charles Dickens" is still at work and taking its full share of some of the heaviest and fastest service on the London and North-Western line. Originally seventy of these locomotives, which have 6-ft. 6-in. coupled wheels and inside cylinders 17 by 24, were constructed by Mr. Webb between the years 1875 and 1882. They did so well that he subsequently converted into the same type no fewer than ninety-six engines having wheels of the same size and similar general dimensions, which had been designed by his predecessor, Mr. J. Ramsbotton, also ninety others which differ only in having wheels 6 in. smaller. All have done, and still do, exceedingly good work, wonderful work in fact, considering their small size and limited nominal tractive force. Excellence of design and construction tells strikingly in this case.

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OUR MONTHLY RÉSUMÉ.

LONDON, 20th October, 1902.

Depression in Shipping.

The depressed condition of shipping is having a bad effect on the shipbuilding industry, the prospect of which grows darker as the winter approaches. It cannot be said, perhaps, that freights are unprecedently low, because a few years ago, before the last "boom" in shipping, they were in many instances quite as low as now. But at that time coal was a good deal cheaper and other expenses were lower. On the whole, it is doubtful if general ship-owning was ever so unremunerative a business as it is just now. The result of the over-supply of tonnage is excessive competition for employment, as most managing-owners seem to prefer running their boats at a loss to laying them up until the clouds roll by. Of course, the cessation of hostilities in South Africa has freed a number of vessels that were engaged in connection with it. One result of the low range of freights is that more iron is being sent across to America from this country than might otherwise have been the case. This drain of iron, and steel, and coal westwards has had an adverse effect on shipbuilders by keeping up the price of material at a time when they would like to reduce costs in order to bring out more contracts. In the North of England the output of shipbuilding material has been sensibly reduced in consequence of the slackness in the shipyards. In Scotland the builders are better employed on current contracts, but are working through these a good deal more quickly than they are securing new work, to which, however, an important addition has been made, to be presently noticed.

Are more Dockyards needed?

Every now and again a cry is raised of the necessity for establishing Government Dockyards in the North of England and in Scotland. A correspondent of the London *Sunday Sun* lately dealt with shipbuilding delays and the congestion in the Dockyards. He says:—

The establishment of a new yard on the East Coast, at Hull or Leith, let us say, would be of obvious advantage. The naval power of Germany is growing. We shall certainly have to provide a North Sea squadron—though we may not call it by that name—and it will then become of infinite importance to base it for coaling, victualling, and repairs on the coast facing the Teutonic empire. The establishment of a great dockyard is ostensibly a costly business, but a fleet without proper bases is of small account. It would be well if the nation would turn its mind away from fascinating expenditure on shipbuilding to provide for more prosaic necessities, such as dockyards and manning. The cost of a naval base upon the East Coast—the money being provided by loan—would be a yearly sum for interest and sinking fund about equal to the price of three-quarters of a battleship, and I think it would be well worth incurring, even if we had to give up a battleship a year to provide it.

But shipbuilders do not want the industry disturbed by the location of dockyard labour among them, nor is the country generally desirous of the extension of the existing dockyard system. The best new work, and the most important repairs are done by contract. There may be political reasons for the retention of Pembroke, Devonport, Portsmouth, and Chatham, but there are economical reasons for not increasing the number. The finest shipbuilding tools, the biggest dry-docks, and the best shipbuilders in the world are to be found on the Clyde and Tyne, at Barrow and Belfast, and in time of war the fighting efficiency of the fleet may depend on the extent to which they could be used. Let the dockyards be reserved for repairs.

Russian Shipping Bounties.

The following is the substance of the new scheme of Russian bounties for shipbuilding. It is proposed to issue loans to shipowners to induce them to build ships at home rather than have them built abroad, and to stimulate the purchase of Russian ships built of Russian material. This will be accomplished by a mortgage on the completed vessel at 50 per cent. of the actual cost, without interest, for a period not exceeding twenty years, repayable in equal yearly instalments. The cost is ascertained by estimating the expense of building ships in Russia according to certain regulations. The amount of the bounty depends upon the difference between the cost of building ships in Russia and abroad. The loans are to be issued to sea-going steamships under the following conditions: (*a*) Plans and specifications of ships must be presented to the Minister of Finance; (*b*) the steamers must rank in the highest class according to British Lloyds' regulations; (*c*) the average speed of boats of over 1,000 tons register must be not less than ten knots on six hours' trial; of under 1,000 tons, not less than eight knots at Lloyds' lower load line. To enable shipowners to repay the loans two measures are proposed. First, the loans will be for twenty years without interest; secondly, the Government will bear part of the expense of insurance. To facilitate the export of Russian goods by steamers built in Russia it is proposed to allow a rebate of half the expense for Russian coal used on all steamers carrying less than three-fourths of a full cargo on export and one half of a cargo on import. It is estimated that the unavoidable calls made on the Government Treasury by these plans to foster home shipbuilding will not be so large as they would be in case of payment of direct navigation and shipbuilding premiums. It was decided that the proposals should first be published in the press of the Russian Empire, in order that the authorities might have the advantage of criticisms or suggestions from interested companies or individuals, but in the meantime it has been decided that all Russian merchant ships shall be registered, and that comparative statements of the methods of navigation in Russia and in other commercial countries of the world shall be compiled.

French Subsidies.

The new French law voted affecting the granting of bounties and premiums to the merchant navy of France has been promulgated. The Minister of Commerce has prepared the draft of a Bill for the mail steamship routes between France, the West Indies, South America, and the West Coast of Africa, for which subsidies are granted. Tenders will be invited for the maintenance of these postal services, after the expiration of the present contracts at the end of next year. The new contracts will be let for a period of fifteen years. All the existing mail steamship lines between France and the West Indies and South America will be maintained, but the Minister proposes to create a new regular service between France and the North of Brazil in order to place France in touch with the basin of the Amazon. The existing service between France and West Africa will be extended. More ports will be called at, and instead of the chief port of the line in France being at Havre it will be transferred to Dunkirk, in order to favour the exportation of the products of the industrial region of the north. Its terminal point on the West Coast of Africa will be at Matadi. The State subvention which will be given for the working of these lines will be twofold, an annual sum and an allocation which will vary with the origin, the age, and the tonnage of the vessels employed, in accordance with the regulations fixed by the new Bill.

New Zealand and South Africa Service.

The New Zealand Government wish to establish direct steamship service between New Zealand ports and South Africa, *viâ* Fremantle, or an alternative service between New Zealand ports and South Africa, with permission, if necessary, to call at another port in Australia *en route.* They invited tenders on the following conditions: There shall be four loading ports in New Zealand in geographical order, and three ports of discharge in South Africa, viz., Durban, Port Elizabeth, and Table Bay, the service to be monthly. The contract to be for a period of two or three years, at the contractor's option. Steamers to be fitted with refrigerators to carry frozen meat and dairy produce. Steamers to be of not less than 4,000 tons measurement, and their capacity for cargo and draught when they are loaded to be such as to enable them to discharge at wharves at above ports. Lighterage, when necessary, to be paid for by contractor. Steamers to have a minimum accommodation for thirty saloon and fifty steerage passengers, and to provide suitable space for mails. The speed of steamers to be not less than 11 knots ocean-going, with penalty and bonus on scale to be arranged, but not exceeding £500 per voyage. The rates for freight from New Zealand ports to South Africa to be not more than as follows: Wheat, 30s.; flour, 30s.; barley, 32s. 6d.; oats, 35s.; bran, 40s.; potatoes in sacks, 40s.; all at per ton weight. Hay, oaten or meadow, pressed in bales, and potatoes in boxes, both at a ton of 50 cubic feet measurement, 37s. 6d. Horses and full grown cattle, £12 10s. each. Frozen meat and dairy produce at current summer rates ruling between New Zealand and London, and other goods at rates current between New Zealand and London. Maximum cargo for Fremantle, which contractors may be required to carry, must not exceed one-sixth of the steamer's capacity, and the rates for freight from New Zealand to Fremantle must not exceed those current from Sydney and Melbourne to Fremantle by more than 25 per cent. Tenders were required to state the period of time required before the berthing of the first steamer in New Zealand, the time to count from the date of acceptance of tender. Tenders were also asked to state what accommodation would be provided for live stock. They were also to state the different amounts of subsidy required per voyage for either or both services. Whenever possible, and consistent with ordinary prudence, and before commencing to load at New Zealand ports, the steamers will be required to call at Westport for a full supply of bunker coal, at which port steamers will have free pilotage and all port charges, excepting light dues.

River Plate Freight Ring.

The increase in freight rates in the service to the River Plate, which was decided upon by the conference of managers of steamship lines held at Ostend, and now in force, will for the present be levied in such a way that primage of 20 per cent. will be collected in the case of goods charged for by measurement, and one of 20 per cent., with an additional 5 per cent. in the case of goods charged for by weight. The rate for cement is fixed at 12½ marks plus 20 per cent. for Buenos Ayres and Monte Video, and at 17½ marks plus 5 per cent. for Rosario. The German steamship companies interested in this trade are the Hamburg South American Steamship Company, the North German Lloyd, Hamburg American Line, and the Bremen Hansa Line. A three years' contract has been concluded, and all the British companies trading with the Plate have joined the combination with the object of maintaining the freight rates already fixed. The increase on outgoing freights will partly compensate owners for the lowness of return freights. The arrangement is not a "Trust," but a working agreement such as railway companies maintain.

A Powerful New Battleship.

Messrs. John Brown and Co., Ltd., Clydebank, have received orders to build the only battleship to be given out to contract under the 1902 Naval programme. She is to be named the *Hindustan*, and will much resemble the *Commonwealth*, now building by the Fairfield Company. Babcock and Wilcox boilers will be fitted for four-fifths, and closed-stokehold forced-draught boilers for the remainder. There will be eighteen Babcock boilers, having 39,000 square feet of heating surface and 1,120 square feet of grate area, while the three cylindrical boilers will have 8,100 square feet of heating surface, and 243 square feet of grate, making a total of 47,100 square feet of heating surface and 1,363 square feet of grate. In the sister ship, to be built at Portsmouth, the total heating surface will be 45,600 square feet, the difference being due to the eighteen Niclausse boilers having 37,500 square feet—the cylindrical boilers being in this measurement similar to those in the other ship. The Niclausse boilers, with 1,393 square feet, have more grate area than the Babcock and Wilcox boilers mentioned above, but those of the cylindrical pattern have the same, viz., 243 square feet. The engines are to be of the triple-expansion type, with four cylinders and four cranks, 38 in., 60 in., 67 in., and 67 in. diameter, with a stroke of 48 in., and a working steam pressure of 210 lbs.

A New Clyde-built Cruiser.

While Messrs. John Brown and Co., Ltd., were signing the contract to build the new battleship described above, Messrs. William Beardmore and Co. were launching at Govan their first contribution to the Navy, the *Berwick*, a first-class cruiser of the "County" type, the fourth vessel of this kind built on the Clyde, although in the same yard their predecessors, Messrs. Robert Napier and Sons, Ltd., built many war vessels. The new cruiser's dimensions are as follows: Length between perpendiculars, 440 ft.; breadth moulded, 66 ft.; draught moulded, 24 ft. 6 in.; displacement moulded, 9,800 tons; indicated h.p., 22,000; speed, 23 knots; boiler pressure, 300 lbs.; normal coal capacity, 800 tons. The vessel has side protection extending over a length of about 350 ft., from the stem to the armour bulkhead, which is 3 in. thick. The side armour is of specially hardened steel of three thicknesses, 4½ in., 3 in., and 2 in., the 4½-in. armour extending forward from the armour bulkhead for a distance of about 240 ft., and the 3-in. armour for a distance of about 40 ft. Between this and the stem there is 2-in. nickel-steel armour. The protective deck proper extends from stem to stern, and ranges in thickness from ¾ in. within the range of side armour to 2 in. outside. This deck is worked at the lower edge of the armour, and protects the vitals of the ship. Another deck, 1¼ in. to 1 in. in thickness, forms a crown over the side armour and armour bulkhead, etc. The coal bunkers range along the sides of the machinery compartments both below and above the lower deck; their normal coal capacity is 800 tons, but this can be doubled if necessary. The armament will consist of twin 6-in. guns, one forward and one aft, mounted in 4-in. barbettes, ten 6-in. guns in hard steel casemates, ten 12-pounders, three 3-pounder quick-firing guns, eight Maxims, and two submerged tubes for 18-in. Whitehead torpedoes. The propelling machinery (supplied by Messrs. Humphrys, Tennant and Co., London) consists of two sets of triple-expansion engines in separate water-tight compartments, each set having four cylinders, working on four cranks, their diameters being 69 in., 37 in., 60 in., and 69 in. respectively, with a stroke of 3 ft. 6 in. There will be an installation of Niclausse boilers for 300 lbs working pressure.

Influence of the Düsseldorf Exhibition.

The Düsseldorf Exhibition* has been so often and so carefully described, that it may be of interest to consider the probable influence of the exhibition on German industries, and the opinions expressed by the various classes of British engineers who have paid it a visit. In considering its influence on the German engineering industry, it is gratifying to remember that at one time England was, in all things mechanical, the teacher of the world. English engineers sank the first coal-pits, built the first locomotives, and may be said to have practically laid the foundation of the whole German engineering industry. At the same time everything German was for many years commonly regarded as cheap and nasty, the phrase "Made in Germany" being looked upon in engineering circles as a kind of danger signal. The Düsseldorf Exhibition has done much to explode this idea, and should have opened the eyes of those engineers who visited it to the fact that the Germans have in many respects proved themselves our equals. The growing demand for German machinery has been evidenced by the large number of orders placed by Englishmen, at the exhibition, and by numerous enquiries for tenders and specifications where the immediate orders have not been feasible. This has been especially noticeable in the mining machinery department. The direct result, as regards the most important German firms exhibiting, will be an almost immediate increase, at remunerative prices, of their export trade, and as the home business is at present in an exceedingly slack state, this increase of foreign business is to them a matter of vital importance.

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* The Dusseldorf Exhibition was closed on October 20th. It was visited by 4,882,459 persons in all, and a considerable surplus has been realised.

The amount of business done is not to be attributed to any remarkable novelties or epoch-making inventions. With the exception of Dr. Thompson's vertical winding engine, the Oechelhäuser gas-driven blast-furnace blowing-engine, and the superheated steam-locomotive, it is difficult to recall anything deserving special mention. The causes for the success of the exhibition must therefore be looked for in other directions, and we shall not be far wrong if we attribute them to the care taken both in the design in the drawing offices, and the accuracy of the workmanship in the shops of the German works. As regards cost, the difference between the English and the German products is not great, in fact, as a rule, it is in favour of the English manufacturer, but the finish given to the German machinery has gained general admiration, and does much to explain the large amount of business done. It is not suggested that English works cannot turn out equally good work, but it has not been the practice to do so. "Show finish" is not known in German workshops, as with a few exceptions all the engines exhibited are exactly as usually supplied by their respective makers. The largest amount of orders appear to have been placed with the makers of machine-tools, many of these equalling the most up-to-date American product. This is especially the case with regard to the smaller classes of machine tools.

Its future Effects.

The exhibition, which was a success both from a financial and business point of view, has served to tide the German engineering industry over a period of depression in their own country, where prices leave a minimum margin of profit, by ensuring them, for some time to come, a continuance of foreign orders at remunerative prices. It must also be remembered that the exhibition is for the most part an exhibition of firms in Rhenish-Prussia and Westphalia, and that some parts of Germany are totally unrepresented. A correspondent who has recently returned from a lengthy tour through the Rhenish-Westphalian district states that on all sides he has heard nothing but expressions of satisfaction at the success of the exhibition and the prospects of future business which it has brought in its train.

German Mining Machinery.

A large number of colliery owners and managers not only visited the Exhibition, but also inspected some of the most important collieries in the neighbourhood, and it may be said at once that the German mining machinery was the subject of astonishment and admiration among those who were new to the German coal-fields. The completeness of the surface equipment, the arrangement and upkeep of the engine rooms, and the discipline and cleanliness amongst the miners called forth nothing but approval. Many managers expressed a desire to follow the example of their hosts, but feared their English shareholders would not consent to such an outlay of capital. Special interest was shown in the pit-head gears and washing plants, which are, perhaps, the best of their kind in the world.

In the ore-mining department much surprise was expressed at the completeness and efficiency of the dressing appliances; this being a special revelation to those mining engineers whose knowledge of ore-dressing was limited to Cornish and similar primitive appliances. Special interest in this branch was shown in the magnetic separators (Wetherill system) exhibited by the Humboldt Engineering Works Co., whereby it is possible to separate ores which, owing to their similar specific gravity, it has not, hitherto, been possible to separate by the ordinary wet-dressing processes. Some of the visitors evidently came over, not with the expectation of being able to learn something new, but more out of curiosity. They went back convinced that, though in some respects they were more than able to hold their own, in other respects they had to learn a great deal.

Railway Amalgamation. A provisional agreement has been signed, subject to the sanction of the proprietors of both companies and of Parliament, for the amalgamation of the Belfast and Northern Counties Railway with the Midland Railway Company. The terms provide for the exchange of debenture and preference stocks of the Belfast and Northern Counties for similar stocks of the Midland Company producing an equal return, while the holders of each £100 of ordinary stock of the Belfast and Northern Counties Company will receive £220 of Midland 2½ per Cent. Preference Stock, producing a secured and permanent return of 5½ per cent. per annum. It is understood that the Irish management of the railway on the present successful lines will be continued, and that the main object of the agreement is the development of cross-Channel traffic, both in passengers and merchandise, through the Midland Company's new port at Heysham, near Morecambe, now rapidly approaching completion.

The Coal Industry of the World. A return has been issued relating to the production, consumption, and imports and exports of coal in the British Empire and the principal foreign countries in each year from 1883 to 1901 as far as the particulars can be stated. It also contains statements showing the production of lignite and petroleum in the principal producing countries for a series of years. The following table shows what has been the production of coal in the five principal coal-producing countries of the world in 1899, 1900, and 1901:—

Years.	United Kingdom.	Germany.	France.	Belgium.	United States.
	Tons.*	Tons.†	Tons.†	Tons.†	Tons.*
1899	220,095,000	101,640,000	32,256,000	22,072,000	226,554,000
1900	225,181,000	109,290,000	32,721,000	23,462,000	240,966,000
1901	219,047,000	108,417,000‡	31,613,000‡	22,074,000‡	260,929,000‡

* Tons of 2,240 lbs. † Metric tons of 2,204 lbs. ‡ Provisional figures.

It will be seen that the amounts produced in 1901 were in most cases less than in the preceding year, though the production of the United States still continues to increase, and has now, for three consecutive years, exceeded that of the United Kingdom. The production of Germany represents less than half, and that of France and Belgium together less than a quarter of the production of this country. The total known coal production of the world (exclusive of brown coal) is now nearly seven hundred million tons (of 2,240 lbs.) per annum, of which the United Kingdom produces rather less, and the United States rather more than a third. The following statement shows the average value per ton of the coal produced taken at the collieries, in the five above-mentioned countries, in the year 1900:

United Kingdom.	Germany.	France.	Belgium.	United States
Per ton.	Per ton.	Per ton.	Per ton.	Per ton.
s. d.	s. d.	s. d.	s. d.	s. d.
10 0¾	8 10	12 0¾	13 11¾	5 5¾

These averages are again in all cases higher than in the preceding year. In Belgium the rise in price amounted to 4s., in the United Kingdom to over 3s., and in France to 2s. per ton. In Germany prices rose only by about 1s., and in the United States by only about 7d. per ton.

Professional Etiquette in Electrical Engineering. The Council of the Institution of Electrical Engineers have issued a circular letter, addressed to the clerks of the principal counties and boroughs of the United Kingdom, in which they have indicated the Institution's views on professional etiquette for consulting electrical engineers. The various points decided are as follows :—

1. No consulting engineer should solicit employment as consulting engineer verbally, by letter, by agent paid by commission or other wise, or by any other means.
2. No consulting engineer should answer advertisements for consulting engineers.
3. No consulting engineer should advertise for employment.
4. No consulting engineer should pay by commission or otherwise anyone who introduces clients.
5. No consulting engineer should receive trade or other discount, or surreptitious commissions or allowances in connection with any works which he superintends.
6. A consulting engineer who is also directly or indirectly interested in any contracting or manufacturing business should inform his client in writing what his connection is with such contractor.

"Ore in Sight." The thanks of the mining community are due to the Council of the Institution of Mining and Metallurgy, who, recognising the great importance to the mining industry and to the public generally of the subject of "ore in sight," a phrase glibly used in mining reports, though it may mean almost anything, have appointed a committee to consider what steps the institution might usefully take in defining the term. After due consideration and discussion the council came to the following decisions :—

1. That members of the institution should not make use of the term "ore in sight," in their reports, without indicating, in the most explicit manner, the data upon which the estimate is based ; and that it is most desirable that estimates should be illustrated by drawings.

2. That as the term "ore in sight" is frequently used to indicate two separate factors in an estimate, namely :—

    (*a*) Ore blocked out—that is ore exposed on at least three sides within reasonable distance of each other —and

    (*b*) Ore which may be reasonably assumed to exist though not actually "blocked out";

these two factors should in all cases be kept distinct, as (*a*) is governed by fixed rules, whilst (*b*) is dependent upon individual judgment and local experience.

3. That in making use of the term "ore in sight," an engineer should demonstrate that the ore so denominated is capable of being profitably extracted under the working conditions obtaining in the district.

4. That the members of the institution be urged to protect the best interests of the profession by using their influence in every way possible to prevent and discourage the use of the term "ore in sight," except as defined above ; and the council also strongly advise that no ambiguity or mystery in this connection should be tolerated, as they (the council) consider that such ambiguity is an indication of dishonesty or incompetency.

NOTABLE BRITISH PAPERS OF THE MONTH.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of Great Britain.

WITWATERSRAND GOLD PRODUCTION.

THE question of the future total production or probable duration of the Witwatersrand Goldfields was ably dealt with in a paper contributed to the Institution of Mining and Metallurgy on the 16th ult., by Messrs. T. H. Leggett and F. H. Hatch. The paper is one of such peculiar interest at the present time that we quote from it at length.

EARLY ESTIMATES.

In dealing with early estimates it is noted that Messrs. Hatch and Chalmers in 1895, forecast a production from the Witwatersrand generally, within half a century, of £700,000,000 sterling. For this estimate an average milling width of 3 ft. was assumed for the whole Rand. The yield was averaged at 38s. per ton, and it was assumed that the reef would be worked down to a vertical depth of 3,500 ft. This estimate was practically adopted by Professor George F. Becker, who visited the Rand in 1896.

Mr. John Hays Hammond, in a paper on Gold Mining in the Transvaal, read at the Richmond Meeting of the American Institute of the Mining Engineers in February, 1901, estimates a total production from the central section of the Rand of £600,000,000, and from the east and west sections of £200,000,000, in all £800,000,000, and further puts "the future duration of profitable operations on a large scale in the district at less, rather than more, than 25 years."* But as Mr. Hammond assumes that profitable mining will be carried on to a depth of 6,000 ft., and states that "there are no factors operating against mining on the Witwatersrand to a depth of at least 8,000 ft. vertically," this estimate of the total production seems under the mark.

More sanguine views as to the probable total production are held by Mr. W. Bleloch,† who estimates the "gold available for practical mining in the area between Randfontein on the west and Holfontein on the east," at 2,871 millions sterling. In this estimate the vertical depth to which mining will be carried is put at 7,000 ft. for the richer central section of the Rand; at 3,000 ft. for the Vogelstruis to Paarl-Central section; and at 6,000 ft. for the remainder. This estimate, it will be seen, is three and-a-half times as great as Mr. Hammond's. The truth probably lies somewhere between these two extremes.

THE METHOD OF ESTIMATING.

In their endeavour to arrive at a fair estimate, the authors assumed that the Main Reef series could be worked to a vertical depth of 6,000 ft. They found it necessary to divide the total area under consideration, viz., from Randfontein in the west to Modderfontein in the east inclusive, into sections, in order to give due weight to variability in yield and reef thickness.

The sections are the following :—

No. 1. Randfontein "A" Block inclusive to Luipaardsvlei (West Boundary).
" 2. Luipaardsvlei (West Boundary) to Grey's Mynpacht, inclusive.

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* *Gold Mines on the Rand*, p. [illegible]. Macmillan and Co.

* On these figures it appears that Mr. Hammond assumes an average annual production for the next 25 years of £800 000 000 divided by 25 equals £32 000,000.

† "*The New South Africa.*" London, W. Heinemann, 1901.

No. 3. West Roodepoort to Durban Roodepoort, inclusive.
„ 4. Kimberley Roodepoort to Bantjes ... do.
„ 5. Aurora West to Paarl Central ... ... do.
„ 6. Langlaagte Royal to Crown Reef ... do.
„ 7. Johannesburg Pioneer to City & Suburban do.
„ 8. Meyer and Charlton to George Goch ... do.
„ 9. Henry Nourse to Jumpers ... ... do.
„ 10. Treasury to Olencairn ... ... do.
„ 11. Knights of Balmoral ... ... do.
„ 12. Ginsberg to Blue Sky ... ... do.
„ 13. Chimes West to Modderfontein Extension do.

For each of these sections the following factors were to be determined :—

(*a*) Average length of reef in feet along the strike.

(*b*) Average "backs" (or length along the dip), in feet, down to a vertical depth of 6,000 ft.

(*c*) Average milling width in feet.

(*d*) Average percentage deduction for unpayable ground, dykes, safety pillars, &c.

(*e*) Average yield per ton, in pounds sterling.

The estimated total production of gold in pounds sterling for any section then is—

$$\left\{\frac{a \times b \times c}{12} = d\right\} \times e$$

AVERAGE YIELDS.

The following table shows a tonnage crushed and the total value of the yield for the mines comprised in each section; also the average value per ton milled—in short, factor *e* :—

AVERAGE YIELDS, 1894-1899.

Section.	Total Tons Milled.	Total Value. £	Value per Ton Milled s.	Number of Mines.
No. 1 ...	727,107	1,343,310	36·95	4
2 ...	973,140	1,733,655	35·62	9
3 ...	1,422,840	3,049,769	42·87	6
4 ...	178,440	221,370	24·81	2
5 ...	1,465,358	2,103,989	28·72	8
6 ...	3,030,500	5,770,070	38·13	5
7 ...	4,405,416	12,237,864	55·56	12
8 ...	1,752,838	2,827,816	32·27	4
9 ...	1,994,712	4,581,111	45·93	5
10 ...	6,808,877	12,159,848	35·72	11
11 ...	624,581	862,451	27·62	2
12 ...	1,059,888	2,334,042	44·04	4
13 ...	1,378,164	2,095,770	30·41	5
TOTALS...	25,821,861	£51,328,065	39·76s.	77

The figures given above are for the Main Reef series only, and do not include yields from the Kimberley Battery, Rietfontein, Black, or other reefs, nor from any of the outlying districts, such as the Nigel, Heidelberg, or Klerksdorp.

THE ESTIMATE.

The following table gives the estimated total production for each section :—

SECTION.		Length along Reef in Miles.	Estimated Total Production.	Amount already Produced to Dec. 31st, 1902	Estimated Future Production.
No.	Extent.				
			£	£	£
1	Randfontein "A" Block, inclusive, to West Boundary of Luipaardsvlei	5·464	124,376,000	1,627,637	122,748,363
2	West Boundary of Luipaardsvlei, to Grey's Mynpacht, inclusive	4·924	115,847,000	2,192,840	113,654,160
3	West Roodepoort to Durban Roodepoort, inclusive	2·273	33,059,000	4,347,032	28,711,968
4	Kimberley Roodepoort to Bantjes, inclusive	3·324	18,197,000	285,710	17,911,290
5	Aurora West to Paarl Central, inclusive...	5·398	97,606,000	3,410,320	94,195,680
6	Langlaagte Royal to Crown Reef, inclusive	1·553	99,765,000	9,125,945	90,639,055
7	Johannesburg Pioneer to City and Suburban, inclusive ...	2·600	231,546,000	20,416,707	211,129,293
8	Meyer and Charlton to George Goch, inclusive	1·756	52,713,000	4,061,352	48,651,648
9	Henry Nourse to Jumpers, inclusive	2·197	94,705,000	5,934,616	88,770,384
10	Treasury to Glencairn, inclusive	3·750	213,423,000	16,606,250	196,816,750
11	Knights to Balmoral, inclusive	1·572	24,180,000	999,794	23,180,206
12	Ginsberg to Blue Sky, inclusive	4·015	107,112,000	2,462,667	104,649,333
13	Chimes West to Modderfontein Extension, inclusive... ...	8·049	97,794,000	2,767,645	65,026,355
					£1,236,084,485
	Banks and Customs Works, etc.	—	—	2,523,776	2,523,776
	TOTALS	46·875	£1,310,323,000	£76,762,291	£1,233,560 709

GROWTH, MAXIMUM, AND DECLINE.

In conclusion, the authors say:—

If it be safe to make any deduction as to the probable duration of mining operations upon a large scale from the foregoing figures, we must assume that the annual production will increase for a few years to a maximum, which will be maintained for a second period, and that there will then be a third period of decline. For the three years preceding the war, the average increase of production was at the rate of £4,000,000 per annum; the production for 1899 being at the rate of about £19,000,000. Allowing 18 months from January 1st, 1902, a similar increase of production will bring the output to at least £30,000,000 per annum by June 30th, 1906, and if this rate of production were to be maintained from then on, the total production of £1,233,560,709 would give a life from January 1st, 1902, of 42¼ years. But as the production will decline gradually instead of coming to a sudden stop, the life of the industry is likely to be prolonged for some considerable number of years beyond the period indicated. If, on the other hand, the annual output should exceed £30,000,000 for any considerable period, as is perhaps within the bounds of possibility, this would partially offset the extension of life due to the gradual decline of production.

It is possible that the yield from certain sections may not be as great as the estimated amounts shown in the table, and again these amounts may be exceeded in other sections. Further, it must be borne in mind that this estimated total yield is vitally dependent upon mining being carried on to a vertical depth of 6,000 ft.

OUR FUEL SUPPLIES.

THE subject under consideration at the opening meeting of the Session 1902-3 by the Institute of Marine Engineers, was that of fuel supplies and their use for engineering purposes, a paper of considerable interest being contributed by Mr. James Adamson, the Honorary Secretary of the Institute. He remarked that the increased and increasing demands all over the world for coal were tending to enhance its value, and at the same time to induce thoughts of its exhaustion. The question then arose: How were we to conserve our supplies and how supplement them by the substitution of another fuel, bearing in mind the fact that almost daily new factories, locomotives and steamships were being started as users of coal?

THE AVAILABLE COAL SUPPLY.

At the present time many steamships used fully one ton of coal per mile run, and it would appear that none too soon a Royal Commission had been appointed to investigate the subject in all its bearings. The amount of coal brought forth in the United Kingdom in the year 1886 was 157,518,482 tons, while in 1900 the amount produced was 225,181,300 tons, being an increase of 67,662,818 tons equal to 42 per cent. The value of the coal at their place of output was £38,145,930 in 1886; in 1900 the total value had risen to £121,652,596, being an increase during the fourteen years of £83,506,666, or 219 per cent. The mean average value based on the foregoing figures showed that in 1886 4·1 tons of coal could be purchased for £1, whilst in 1900 only 1·8 tons could be purchased for the same money. In other words, one ton of coal in 1886 cost 4s. 10½d., but in 1900 the same amount cost 11s. 1¼d., an increase of 6s. 2¾d. per ton. Considerable interest also attached to the figures relative to the exports of coal and patent fuel during the years 1886-1900. In 1886 23,283,389 tons were exported, whilst in 1900 the amount of exported fuel had risen to 46,098,228 tons, an increase in fourteen years of 22,814,839 tons, or 98 per cent. The value in 1886 of exported coal and patent fuel was 8·32s. per ton; in 1900 the value had risen to 16·52s. per ton, an increase of 92 per cent. It was a safe presumption that most nations were increasing their consumption, some of them in greater ratio than our own country. Coal was found in almost every land, and in varying qualities, Welsh coal being a standard approximated to, more or less, by the best of other lands, but owing to its special qualities for steam-raising purposes its value was always in advance. In South Africa recently, Natal coal was 29s. per ton, and Welsh coal 36s. At several ports where formerly Welsh coal was used it had been superseded by native coal, owing to the Welsh coal reaching a price which was beyond the equivalent value of the native article. This was especially the case in Australia, China, Japan, India, America and South Africa. According to the mean of various approximate computations, our stock of known coal-fields would last for about 400 years. Since these computations were made, the consumption and output had materially increased, and if it continued to increase the end would approach all the more rapidly, the price increasing as the coal became scarcer. The appointment of a Royal Commission to investigate and consider the whole question of the country's fuel supply, the methods of using same, with a view to economy, and to discover what classes of fuel could be substituted for coal, showed that the Legislature considered it advisable to take some steps in the matter.

POSSIBLE RESTRICTIONS OF COAL CONSUMPTION.

Discussing the various methods of restricting the consumption of coal without violating any principle of right or of political economy, Mr. Adamson named the following:—

(1) Economising in the burning of coal; (2) adopting the best methods of utilising the products of combustion; (3) utilising to the best advantage the elements, whether steam, water, or electricity, brought into service from the fuel; (4) maintaining in the highest efficiency the machinery whose motion is directly due to the fuel used; (5) testing and adapting other fuels as substitutes for coal; (6) testing and utilising the refuse heaps from mines, where such exist, for use in certain purposes where an evaporative power was not of such moment as in a

steamship; and (7) experimenting with and testing the refuse from sewage works with a view to making use of the combustible portions. Various schemes had been brought forward from time to time to use our water power both river and tidal, to a greater extent. There was no no doubt that wherever possible water power should be utilised. Heads of water were now made use of for generating electric plant in some parts of the country, and its greater use should be encouraged for economic reasons.

PEAT CHARCOAL.

Mr. Harrison, after describing the experiments which were made some years ago with a view to produce peat charcoal for commercial purposes, having regard to its fitness for smelting works, pointed out that—

So far as could be ascertained, the circumstances which prevented the manufacture of peat charcoal and fuel as a commercial success were the cost of production and the want of sufficient capital and enterprise to carry the venture to a successful issue. Possibly with fresh light thrown on the best and most economical process for the manufacture and treatment of the peat, success might now attend their efforts where failure previously obtained. The analysis of the test sample of peat charcoal resulted as follows: Carbon, 79·54 per cent.; ash, 3·51 per cent.; sulphur, 0·46 per cent.; volatile matter at red heat, 6·84 per cent.; and moisture, 9·71 per cent. The sample tested had been prepared in the laboratory of the chemist to find out what process would be necessary to prepare the peat for the market, the most suitable plant for preparing it, and the probable cost. On further drying the test sample the carbon was increased to 88·63 per cent., and the sulphur reduced to 0·44 per cent. For smelting and forging purposes a fuel with so small a percentage of sulphur was very desirable. Save for the large percentage of moisture, the extraction of which was one of the difficulties in preparing peat fuel for the market, peat charcoal stood in a good position relatively, in so far as the analysis went. If they took the price of coal at the time the experiments were made, and the price at the present day, they would be able to see the difference in the relative commercial values, and be able to gauge to some extent the prospect of peat being now introduced with success. The estimated cost of peat charcoal containing 0·44 per cent. of sulphur was 80s. per ton. In 1889 the estimated cost of coke containing 0·9 per cent. of sulphur was 14s. per ton, whilst coal containing 0·5 to 0·6 per cent. of sulphur was 7s. per ton. In 1902 the cost of coal, with a smaller percentage of sulphur, suitable for smelting purposes, was 10s. 6d. screened, and 8s. 6d. unscreened. As time went on, and improved methods of dealing with peat were discovered, the cost of coal also increasing, the relative prices of peat charcoal, coal, and coke would approximate to one another more closely. The bye-products obtainable from peat showed that one ton produces 13,000 cubic feet of gas free from sulphur, 16 lb. acetic acid, 46 lb. wood naphtha, 20 lb. sulphate of ammonia, 12 lb. paraffin wax, and a quantity of tar. By a recently patented process for the compression of the peat fibres and extraction of the moisture, the time and machinery necessary had been greatly reduced. It was hoped that in the near future a preparation of peat would be available for steam purposes at little more than half the price of coal, with a stowage capacity only slightly in excess of coal, and of very little less calorific value.

In the course of the evening's discussion, the Chairman (Mr. M'Laren), said he would have liked to hear more from Mr. Adamson regarding liquid fuel, which was now all the rage. Mr. G. W. Newall remarked that attention had been drawn to the question whether a ship of a few thousand tons might not be propelled across the ocean by electricity. The dream, or rather the ideal, of the electrician was to use a generator ashore, and—if it might be so expressed—to have a sympathiser on the ship; then to transmit through the ether electric force under the control of the men on the vessel, and so work the engines without the use of coal at all.

STANDARDISATION OF PIPE FLANGES AND FLANGED FITTINGS.

SOME time ago a paper on the dimensions of flanges for steam-pipes and the standardisation of pipe flanges and flanged fittings was read by Mr. R. E. Atkinson before the Institution of Mechanical Engineers. The Institute of Marine Engineers were invited to give the subject their attention and transmit to the Institution of Mechanical Engineers the results of their discussion, to aid that institution in arriving at suitable standards. Accordingly, at a recent meeting of the Institute of Marine Engineers, a paper on the subject was read by Mr. Ruthven, who, in the course of his remarks, emphasized the importance of interchangeable fittings.

It was well-known that no two makers supplied interchangeable fittings; the most to be looked for was that a maker would always stock fittings that would fit when they supplied the original parts. For the buyers it would be of great value if they could at once purchase fittings that would take the place of broken pieces. Whether this would be equally to the advantage of the makers was another question. He was of opinion that if buyers desired interchangeable flanged pipes and fittings they would have to employ inspectors to test and mark them, in the same way as was done with standard weights and measures. In adopting any standard for this purpose it was evident that fittings would be too heavy in the majority of cases. Fittings that were required for work at 100 lb. pressure would be too heavy for 10 lb. pressure, and, consequently, the weight and price would be heavier than if the fittings were made specially for the job. If buyers of steam fittings would decide to buy from one maker only, there need be no difficulty, for under these circumstances any of our great makers could arrange to have their goods procurable in all the chief ports, and soon the smaller makers would be obliged to follow. He thought this would be the quickest way to get a universal standard. The chief points for discussion were (1) Should the diameters of flanges be one diameter for each size for all pressures? (2) Should the number of bolt holes for each size be constant? and (3) the question of the position of the bolt holes for all sizes. Regarding the number of bolt holes, the author of the paper read before the Institution of Mechanical Engineers was of opinion that the number should in every case be divisible by four, and that the holes should be drilled off the centre line of valve or fitting, and symmetrically on each side of it. To get over some of the difficulties of various standards of measurement, it might be convenient to give pipes and fittings a standard number or letter, and so, when ordering a fitting in this way, the new part would always fit. For standardisation to be of the greatest value the fittings would have to be made for the highest pressures. He understood that it was not proposed to make standardisation compulsory, so that any design for special cases would not interfere with a system of standardisation. It would be a question of cost and convenience; in some cases there would be a saving by special designs, and in other cases by standards. He thought that the buyers of small fittings would be the first to find the benefit of standards, and a combination of manufacturers of such fittings would soon accomplish this. On large contracts, and where great numbers of fittings for particular work were required, the designer, would have to use his talents and make the most of his materials; that was to say, he would have a standard of his own for each case. The subject was one of great interest, whether it were decided for or against standardisation under all circumstances, or to meet special conditions. The points to be considered were convenience, efficiency, cost and weight.

THE STATUS OF THE NAVAL ENGINEER.

AT the meeting of the North East Coast Institution of Engineers and Shipbuilders, held at Newcastle on October 24th, Mr. John Tweedy, J.P., in the course of his presidential address, dealt with the question of reform in the organisation and training of the engineering *personnel* of His Majesty's Navy.

It is interesting to remember that the machinery of the Navy did not originate within the service. It was originated, and has been developed and perfected, and is to a large extent manipulated by members of the engineering profession represented by this and kindred Institutions. It is still designed and constructed by such members, and they are still, both professionally and financially, responsible up to a certain point for its efficiency. It is also to be remembered that the problems involved, not only in the design and construction, but also in the operation of the complicated machinery, become daily more abstruse, and recede more and more from the comprehension of the non-technical mind.

At present the engineer officer is not an executive officer, he holds no rank. He is a layman, a capable technical expert in much the same position on board a warship as a guarantee engineer on board a foreign merchant steamer, active in the purely technical duties of an officer, but still not an officer endowed with the necessary executive powers in his own department, which experience points out as being absolutely necessary for efficiency. Lord Goschen has described a modern warship as a fiendish complication of machinery. Professor Weighton says of it, that it is perhaps the most awe-inspiring aggregation of power in one unit yet devised by man. No one having the least knowledge of the subject will consider either of these descriptions exaggerated, but only engineers of experience can fully appreciate the great responsibility, even in times of peace, resting upon the men in charge of such machinery. Captain Mahan, probably the best known and ablest writer on naval matters, has said that "historically, good men with poor ships are superior to poor men with good ships." In other words, the degree to which the latent fighting value of naval *materiel* can be rendered effective, is determined by the sufficiency, skill, and experience of the *personnel*. Improperly handled, the most perfect machinery, like the finest ship, may become a source of weakness instead of strength to a nation.

We believe Captain Mahan's historical deduction to be sound. We know, as engineers and shipbuilders, that Lord Goschen's and Professor Weighton's descriptions are accurate, and I think we must conclude, as engineers accustomed to the design, construction and operation of complicated machinery, that if the best is to be made of the *materiel* of the Royal Navy, if the nation is to avoid the dissipation of its resources without adequate return in effective work, it is imperative that, in this branch as in all other branches of the service, the *personnel* shall always be in advance of the known immediate requirements of the *materiel*, that as the *materiel* increases in amount, dimensions, and complexity, so must the standard of entry be raised, and that, whether in future the officer in charge of the machinery be a sailor, or a gunner as well, he must at least be specially educated and trained as an engineer, skilled not only in the operation, but also understanding the design and construction, and therefore the possibilities and limitations of the machinery in his charge.

No one doubts but that the present Admiralty Board is actuated by the keenest desire to place the department on a sure foundation of efficiency, but the Royal Navy is so vast a machine, its organisation so intricate, so rusty with age, and the legacy of difficulty inherited by its present members so great, as to make unaided movement exceedingly difficult and perhaps hazardous. It is to be hoped, therefore, that the Admiralty Board will strengthen itself in regard to this question by appointing a strong Commission, composed of experts from the inside and a few competent persons from the outside, to consider and report to them upon the whole question.

REVIEW OF LEADING CONTINENTAL PAPERS.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of the Continent.

A NEW GAS-ENGINE.

THE new Niel motor, which was lately tested by Prof. A. Witz and M. A. Moreau, formed the subject of a communication by the latter to the French Society of Civil Engineers, of which the following is an abstract.

In this 4-period engine the efficiency has been improved and the gas consumption reduced by a judicious increase in the compression (varying from 10 to 12 kilogrammes per square centimetre, or 142 to 170 pounds per square inch) of the gas and air mixture, which is effected in a special chamber, arranged in a movable breech-piece (the only part that overhangs), at the back of the cylinder. Notwithstanding this high compression, however, the lighting gas of a town service may be used, provided it be diluted with a far larger quantity of air than usual, so as to constitute a gas almost as poor as that of a producer, in order that the motor may work with poor or service gas at will by merely changing the admission valve. Water circulates between the cylinder and its jacket, first cooling the exhaust valve; and there is great saving of water, owing to the jacket being reduced towards the front of the cylinder, where there is less necessity for cooling, and where the water issues.

The 45-horse engine tested has a cylinder of 35 centimetres (14 in.) diameter, with 48 centimetres (1 ft. 7 in.) stroke; and the fly wheel, 2·2 metres (7 ft. 4 in.) in diameter, makes 216 revolutions per minute, the capacity of the cylinder being 0·0485 cubic metre (nearly 2 cubic feet) and the explosion pressure from 22 to 25 kilogrammes per square centimetre (313 to 355 pounds per square inch). The distribution is effected by vertical valves, that for exhaust with invariable rise, being at the lower part of the breech-piece in a movable seat easily renewable.

The air and gas are led up by two independent passages fitted with slides that permit of regulating the proportions roughly, while the final regulating is effected by two valves, of which the lower serves to introduce the mixture into the cylinder. The quantity admitted can be regulated by the centrifugal governor (acting through a very sensitive dashpot) that constitutes a vacuum cylinder during the aspiration and a compressor when the valve closes. The gas valve, fastened by a socket to the same spindle as the above, follows all its movements; but it has a constant and maximum opening, while the explosive-mixture valve only has a minimum opening, so that, the slighter the rise of the latter, the greater will be the proportion of pure gas in the mixture, and so much the more as the gas has a slighter density and greater pressure than has the air drawn in.

This is a highly important matter, because when the inlet valve introduces less mixture owing to the governor's action, the compression is naturally slighter and the explosion less intense. With poor gas especially it might be feared that the ignition would not be effected regularly; but, at the same time, there takes place the methodical enrichment of the mixture by the proportion of gas being increased, so that no failure occurs in the ignition.

There is, therefore, an admission at each stroke; and a regulating is obtained based upon variable compression, producing explosions of different intensity, but leaving a constant speed with as perfect regularity as possible whatever be the load on the engine. Some trials during ten consecutive hours showed the consumption of service gas to be 439 litres (15½ cubic feet) per h.p. per hour; and, in a trial somewhat less prolonged, M. Deschamps found 445 litres (15¾ cubic feet). The latter seized the occasion of M. Moreau's communication to offer a few observations on the following subject.

THE EFFICIENCY OF GAS ENGINES.

The thermal, organic, generic, economic, specific, and other yields are co-efficients, the value of which it is very difficult to determine because they are not constants of the motor, and, even for a given speed and fuel, vary considerably with the motor's power. Gas-engine trials have shown that the consumption, C_n, varies with the power n very nearly according to the equation

$$C_n = C_v + \frac{n}{N} (C_n - C_v),$$

C_v being the consumption when the engine is running light and C_n that when fully loaded, while the formula may also be written—

$$C_n = N \left(\frac{C_v}{N}\right) + n \left(\frac{C_n - C_v}{N}\right).$$

M. Deschamps proposes to take as parameters for a given motor $\frac{C_v}{N}$, which he calls the specific consumption when running light, and $\frac{C_n - C_v}{N}$, which he calls the reduced consumption per h.p.—*i.e.*, the quotient by the number of h.p.'s of the difference between the consumption loaded and the consumption light, this value being about the same whatever be the power taken for determining the full load. Although the above formula is only approximate, the two co-efficients given have a value independent of the motor's size, being constants for all motors of one and the same family.

The idea of a generic yield—*i.e.*, the comparison often drawn between a motor's yield and that which would be obtained by making it traverse a Carnot cycle between the same extreme temperatures as those attained in the motor—is a dangerous conception, because the gases in a motor do not pass through a cycle, while this cycle could not be reversible, and especially because we only have a conception of absolute temperatures considered in the Carnot cycle through the definition of that cycle.

HALF-CROSSED BELTS FOR HIGH POWERS.

Just as, in the early days of the locomotive, a rack rail was thought necessary to secure adhesion and progression, so, previously to about thirty years ago, spur gear had such a predominance over driving belts that (in France) most steam engines were made with toothed flywheels for directly driving shafts and machines, while bevel gear was employed in preference to half or partially crossed belts, whenever there was a deviation from the straight line in power transmission. Since that period, the use of half-crossed belts has become general, although they have rarely been employed for transmitting more than 20 h.p.

Two instances of more considerable power transmission by half-crossed belts (50 h.p. in one case and 80 h.p. in the other) were, however, brought by M. Albert Smits before the *Société Industrielle du Nord de la France*, such arrangement having been adopted on account of the frequent breakage of hardwood teeth in the bevel gear previously employed; and these cases are all the more interesting because the resistance opposed by the work is very irregular.

In the 80-h.p. transmission a 2-ply leather belt, 30 centimetres (12in.) wide, is glued over the whole adherent surface and stitched at both edges, while the ends are bevelled off and glued, so that the thickness is no greater at the joint than elsewhere—a matter of vital importance in cases like the present, because increased thickness, and, therefore, increased weight, would cause sagging at the changes of direction, thus setting up additional strains, and at length bring about destruction of the belt, especially with high speeds.

In this case the driving pulley, 1·16 metre (3 ft. 10 in.) in diameter, makes 240 revolutions per minute; and that driven, 1·4 metre (4 ft. 8 in.), 192 revolutions, while the distance between the centre lines of their shafts is 5·1 metres (17 ft.). The rims of both pulleys are 35 centimetres (14 in.) wide, and rounded with a rise of 10 millimetres ($\frac{13}{32}$ in.), the plane of greatest diameter being shifted 20 millimetres ($\frac{13}{16}$ in.) on the side farthest from the other pulley, with the object of preventing the belt from falling when started, and especially when stopped.

As regards the relative position of the pulleys, the lower one, driven, is arranged so that its periphery is 80 millimetres ($3\frac{5}{32}$ in.) laterally from the median plane of the driver, instead of coinciding with it, as had previously been considered the correct practice, but which trials have proved to be erroneous; and, indeed, it is necessary, when driving with half-crossed belt, to leave between the two pulleys a free lateral space, that necessarily varies with the distance between the shafts, the width of belt, and especially its speed.

In the second case, the dimensions are the same as in the first; but, as the power transmitted is only 50 instead of 80 h.p., the belt is single-ply, its ultimate resistance to tensile strain being 18 kilogrammes per square centimetre (256 lbs. per square inch) against 29 (412) in the first case. Instead of being cut straight from the hide, as usual, the belts were set out to a slight curve, so that one edge is shorter than the other.

Under the conditions set forth, both belts have given perfect satisfaction, although, previously, a cotton belt and a sewn leather belt of ordinary quality soon gave out, so that the author considers the outside limit has been reached as regards distance between centre lines of the shafts, pulley diameters, and width of the belts.

IMPORTANCE OF THE TIME FACTOR IN MINING.

DURING a scientific tour in England, M. de Gennes visited the Creswell, Cadeby, and Normanton Collieries, and was much struck with the arrangements for winding that permit of intensive working, and which in all probability suggested his observations to the *Société de l'Industrie Minérale* as to the value of rapidity in mining operations.

In French mines, under the designation of *prix de revient* (cost of getting), detailed statistics show what it has cost to put out a ton of ore or coal—a very important matter, as everyone knows; but there is another that appears to have been more or less overlooked by mine owners, and which must be regarded as of almost equal importance. This is the space of time in which each mining operation is accomplished, and which the author calls the "time factor," while leaving to the other the designation of "cost factor." The time factor is, unfortunately, far more difficult to establish; but every mining engineer can modify and arrange it so as to suit his own requirements, although it ought always and everywhere to be taken into consideration, as will be evident from the following examples.

If mine explorations over a given area afford the same result in a month with greater expense as in a year with less expense, the former will certainly be more economical, for during the eleven months following the more rapid results the capital will not have been lying idle, works may be undertaken that will cause it to fructify more quickly, and so forth.

If, when the works to be undertaken are determined, a shaft be sunk so that winding can begin, and if this shaft be finished in half or one-third the usual time, but by more expensive means, even twice or three times more expensive, a real saving will have been affected.

In the case of a coal seam taken horizontally, or with a certain dip, as in the Nord and Pas-de-Calais (the whole seam being taken), or by horizontal stages, as in the Centre of France, if advance be made in the seam at right angles to an indefinite working face, we know that at a certain distance behind this face—distance dependent on the individual conditions of the seam and the method of working it—pressure will come on the roof and render its support very difficult, or at any rate very costly. When the first or forward workings are in advance of the second or return workings, the more numerous they are the more difficult does the support of the roof become, especially at the point where the forward workings leave the face of the return workings, so that there is advantage in diminishing the former, or even in suppressing them if possible ; and long-wall working is well-known to be economical as regards timbering and the production of large coal.

Independently of forward workings, the great rapidity with which advance can be made in the coal, leaving the line of pressure behind, is afforded by mechanical coal-cutting, which permits, at any rate in some cases, of passing under the roof before the pressure comes on, and in others of approaching that ideal which economises timber, and may even dispense with it, while producing larger coal of greater market value. Mechanical means may be as expensive in actual cost as getting by hand ; but they afford a saving, or at any rate a better utilisation of labour, while, if the time factor be taken into consideration, it will be found that the working out of a district will lead to economy in all the accessory services.

ELECTRIC CRANES AND CONVEYERS.

SO long as only steam or water under pressure were available for affording power, the steering crane was the only rapid-working appliance for raising weights. This form of crane has the great advantage that the heavy gear can be arranged in close proximity to the axis of rotation, so that mass resistances due to horizontal movement of the driving gear are only set up to a very slight extent; and for working by steam the travelling and steering crane permitted of the boiler being placed at a readily accessible height. Electric working took over the steering crane in its condition at the time; and at first the adaptation was confined to a better distribution of the power. The steam crane, with its duplex engine, had united the whole driving gear at one point, in order to make a single motor suffice for the several operations, thus entailing a clumsy and complicated construction that gave the impression of clockwork rather than of a machine. Electric working, with its simple and easily reversed motor, again dispersed, or distributed, the driving gear, placed the application of power as near as possible to the point where the resistance occurs, and did away with all unnecessary mechanical parts for power transmission, so that the whole design was simplified, greatly in favour of maintenance and working.

These observations were made at the Düsseldorf meeting of the *Verein Deutscher Ingenieure* by Herr Kammerer, of Charlottenburg, who brought forward examples of electrically-worked T-form swivelling crane for heavy loads, crane with lowering jib for loading and unloading vessels, overhead travelling hoist, foundry cranes, a travelling crane remarkably like a grasshopper, and aerial ropeways, remarking that they will shew the crane-maker he has to hand a new electro-technical expedient which affords the inducement to bring out new designs and extend his field of operations, concluding as follows :—

The individual feature of these machines, of unlimited scope, evidently consists in the fact that a form of energy is employed which is unusually mobile and supple ; and the naked *Kontaktleitung* is the simple mechanical element which alone renders possible this remarkable departure from previous and traditional arrangements. With other agents of power transmission, lifting appliances can only with difficulty be produced that pass over curves of any form and tracks of any length, that carry with them their required energy for application at any point in the line, and that can be reversed from far or near. Additional importance is also lent to this question by the fact that, of all manual operations, that of moving heavy weights is the most thankless and least remunerated.

COKE AND BRIQUETTED IRON ORE AT THE DÜSSELDORF EXHIBITION.

THE coke-oven exhibits at Düsseldorf are interesting because a great many ironmasters make their own coke, employing the type of oven best adapted to the coal at their disposal ; and by-product recovery, now generally applied, is of first importance, because it affords means for reducing the cost of making pig-iron, observes M. Alexandre Gouvy to the *Société des Ingénieurs Civils de France*, in his exhaustive report on Iron and Steel Metallurgy at the Düsseldorf Exhibition.

VON BAUER COKE-OVENS, much appreciated in Germany, where they dispute the first place with the Otto ovens, are made by the Rhenisch-Westfälisch Coak-Oven Aktien-Gesellschaft, with the special object of (1) obtaining a yield only 10 per cent inferior to that in the laboratory; (2) treating large charges—as much as 10 tons of coal tipped into the oven or 12½ tons of compressed coal; (3) reducing the carbonisation to a minimum—from 24 to 48 hours, according to the quality of the coal; (4) affording ready control of the operation, while producing good coke and suppressing smoke, with consequent loss; and (5) reducing maintenance of the ovens while permitting recovery of the by-products if required.

OTTO-DAHLHAUSEN COKE-OVENS.

This company attaches greater importance to by-product recovery; and the Otto ovens are now provided with special gas-burners, while regenerators are entirely abandoned. A group of four oven-compartments has been erected full size in a special pavilion, while a model to 1:40 scale in the Mines Department represents a complete coke-oven plant, with screening and washing floors and the Shamrock pit bank of the Hibernia Company. Since 1876, when the Otto Company was started, it has built on the continent of Europe, in addition to those in America, 12,168 coke-ovens, including recovery and non-recovery ovens, and also those of 1896 type. In the latter the makers start from the principle that the combustion of large gas masses at a single point must be avoided, that each heating (*chauffe*) should have its special and adjustable inlets for gas and air, and that the path traversed by the gas should be as short as possible. The present ovens are 10 metres (33 ft.) long, from 1·9 metre to 2 metres (6½ ft.) high, and of a width varying with the quality of the coal from 43 centimetres (17 in.) to 60 centimetres (24 in.), while the coking is considered to last from 28 to 32 hours.

THE BRUNCK-DORTMUND COKE-OVENS, brought out in 1893, are characterised by (1) double and vertical heating flues between the oven compartments; (2) a solid wall between two compartments that permits of increasing their height, of making them narrower without abandoning large charges, and of reducing the length of carbonisation; (3) the separate heating of each oven and re-heating of the air for combustion; and (4) a construction that facilitates the effecting of partial repairs. These ovens are 10·25 metres (33½ ft.) long, from 2 metres (6½ ft.) to 2·25 metres (7½ ft.) high, and from 43 centimetres (17 in.) to 55 centimetres (22 in.) wide, according to the coal, while the charge varies from 5 to 7½ tons for a coal containing from 10 to 15 per cent. of water, and the operation lasts from 26 to 34 hours.

THE MAKING OF FINE ORE BRIQUETTES offers great interest in some cases because it permits of charging into the blast furnace larger quantities of cheap ores, especially pyrites residue, the most suitable binding substance being hydraulic lime. All coal briquette presses may be used for this purpose provided they afford sufficient pressure; and M. Gouvy found at the exhibition two presses that appeared suitable owing to the comparative simplicity of their construction.

THE TIGLER-MEIDERICH PRESS, with L-leg, or bent lever, worked by a crank-shaft, affords three-fold compression, viz., by impact through the free fall of a stamp, pressure of the lower portion, together with equal simultaneous pressure upwards and downwards, and can turn out 20 tons of 12-kilogramme (26 lbs.) coal briquettes per hour with a 12-horse motor, while, by changing stamps and dies, briquettes varying from that weight to only a few ounces can be produced.

THE DUNKELBERG BRIQUETTE PRESS, which can make ten tons of coal briquettes per hour, appears to have been chiefly used for fire-clay goods, but is very suitable for briquetting iron ore. The maker claims for this press a gradual increase of pressure, equal above and below, up to the maximum, which is maintained for a determined space of time; and the action is due to a bell-crank, in which is lodged a roller that transmits the motion.

THE PROGRESS OF MACHINE-BUILDING IN RUSSIA.

THE *Russkoe Bagatstvo* for October (Sept. 30), contains an article of some interest by Mr. P. Kozmin, a well-known Russian writer on industrial questions, on "Russian Machine-Building in Its Relations to Protectionism." The question which the writer sets himself to solve is why, notwithstanding the vast development of the Russian iron industry, the supply of machinery, and especially agricultural machinery of the more complex kind, is so small in comparison with the import. During the ten years, 1890-1900, the production of pig-iron in Russia increased from 56,600,000 puds to 175,500,000 puds; that is more than threefold, while in the Donetz region it increased no less than sevenfold. Despite this increase, the Russians are quite unable to supply their own market with the agricultural machinery which is demanded for its economic development, and are obliged to import increasing quantities from abroad.

Mr. Kozmin finds an explanation of this in the unnatural way in which the internal market has been worked. The manufacturers have been entirely dependent on State and municipal orders for which they get high prices, but have been unable to supply the home market under competition with foreign firms, owing to the extravagant price of raw material resulting from the high customs duties. In 1899, out of 163,000,000 puds of iron and steel, no less than 95,840,000 found an outlet in railway construction and repair. Only 41 per cent. of native-produced iron remained for all other purposes. A large proportion of that went upon tramway construction and municipal undertakings, and upon the equipment of the smaller factories with machinery, the great factories and workshops almost invariably importing their machinery from abroad. After these requirements were supplied, hardly any native iron remained for agricultural machinery, and all the other wants of the private consumer. Yet for agricultural purposes alone the yearly demand is for 110,000,000 puds. The Russian consumer therefore turns his face to the foreign manufacturer, and the iron industry develops entirely without relation to the private consumer.

Yet Russia at present contains 490 machine-building and engineering work-shops, and 207 engaged in constructing agricultural implements and machinery. The apparent inconsistency between these considerable figures, and the failure of the Russians to supply the agricultural market is explained by the fact, that hardly ten of the latter class of workshops are large or equipped in modern fashion. Nearly all the mills in Russia are equipped with machinery by the firm of Erlanger, which has stores in twenty towns. Russian machinery plays practically no part in saw-mills or parquet factories. The whole production of the 207 agricultural-machinery firms is valued only at 13,627,000 roubles, a figure which is largely exceeded by the value of imports.

The seriousness of the present crisis in Russian machine-shops is shown by the fact mentioned by Mr. Kozmin that the number of employees has been reduced by half. . . . At the Kharkoff Session of Machinist-Engineers, this decline was explained by the insufficiency of the Customs Duties, and a demand was made for more Protection. Mr. Kozmin points out that the Russian economist, Tugan-Baranowsky, maintains, on the contrary, that "Protection has not only not fostered, but has ruined the Russian iron industry." With this view Mr. Kozmin agrees. But he argues that the real cause of Russia's misfortunes in this respect is not the duty on imported machinery, but the exorbitant prices which result from the dearness of native raw material. The result of these high prices is that not only agricultural machinery, but even modern implements are out of the reach of the poorer consumer altogether. The metallurgical works flourish owing to the protection of raw material; but the machine-shops decay. There is only one way to encourage the engineering firms, and that is "to lower the duty on raw materials to a tolerable figure."

The importance of this article for England as an exporter is very considerable; as it is admitted by Russian economists that Russia will never become a great purchaser of foreign manufactured goods until the technique of agriculture and the well-being of the peasantry are improved.

A RUSSIAN VIEW OF THE SIBERIAN RAILWAY.

THE *Russian Economic Review* for October contains the conclusion of a series of papers on "The Influence of the Siberian Railway," from the pen of M. P. Krasnoff. Most of these papers deal with the effects of the railway upon the economic condition of the country; but the concluding article also contains some calculations as to its exploitation, and the prospect of profit, which are not without interest. M. Krasnoff's conclusion is pessimistical. Taking into account the vast cost of the railway, some 780,000,000 roubles, he says it is not possible to expect it to bring in any profit under present conditions. Calculating interest on capital, and provision for extinction at 4½ per cent., nearly 34,000,000 roubles profit would be required from the exploitation. In 1899, the working of the railway cost 5,000 roubles a verst; but taking into account the Chinese Eastern Railway, future exploitation will cost at least 6,000 roubles a verst. As the total length of the railway is 7,762 versts, the working expenses will amount to 47,000,000 roubles a year. Hence, to cover expenses and interest, the railway must have a gross revenue of 80,000,000 roubles, and carry not less than 400,000,000 puds of freight. To cover working expenses alone, 166,000,000 puds would have to be carried. But, in 1898, the railway transported only 37,000,000 puds; in 1899, 40,000,000 puds, and, in 1900, 45,000,000 puds. The growth of transport must, therefore, be enormous before the railway can pay its way.

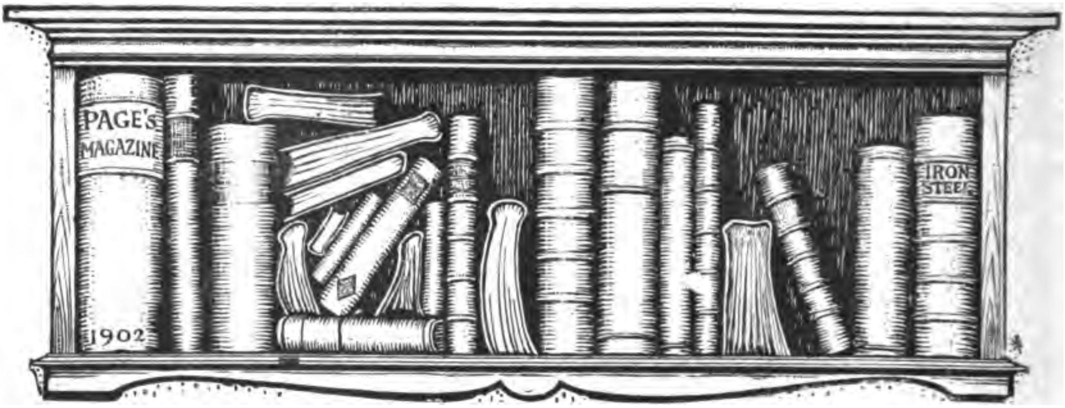
Against this pessimistic view, M. Krasnoff sets figures as to the rapid development of the Canadian-Pacific line, and the railways in New Russia. Moreover, immigration into Siberia increases rapidly (at about 200,000 a year); and though this traffic does not directly pay, it must bring with it a vast increase in the goods traffic. But, on the whole, it is local and not long-distance freight which has most developed in Siberia of late years.

The *Eastern Review* declares, on the other hand, that there has been no growth in the well-being of the Siberian population since the railway was begun. The emigrants who now flood the country in no year brought with them an average of more than 16 roubles a head. A great deal of the economic enlivenment of the country during the last few years was caused by the vast armies of engineers, contractors, and officials; but no industries worth mentioning have developed. The general level of well-being of the population has fallen steadily.

In connection with the Siberian Railway it is interesting to note that a heated discussion has been going on in the Russian Press as to the merits and demerits of the route at present selected for the railway around the south coast of Lake Baikal. A Russian engineer, M. Makeroff, has suggested a change in the route, maintaining that the cheapest way to solve the problem would be to construct a canal about 120 versts above the confluence of the Irkut and Angara, diverting the former stream directly into Lake Baikal; and to build the railway through the hilly country along the dried-up valley. Taking the length of the line as 317 versts, M. Makeroff maintains that the adoption of his plan would result in a saving of 20,000,000 roubles.

THE MANGANESE INDUSTRY OF THE CAUCASUS.

THE manganese industry in the Caucascus is reported to be suffering from a severe crisis owing to the refusal of the railway authorities to listen to the representations of the miners. The chief complaint made by those interested in the industry is the extravagant tariff exacted for the transport of the metal by the Tchiaratura branch of the Transcaucasian Railway. The present rate is 7 kopecks a pud, which operates as a special tax upon the industry. Nearly the whole of the government of Kutais depends upon the manganese industry, and as the trade is, from other causes, extremely depressed, the high tariff, several times greater than the normal, weighs heavily upon the producers.



SOME BOOKS OF THE MONTH.

In this department special attention will be paid to all books dealing entirely or in part with subjects within the *purview of the Magazine*. While space will be given for expressions of opinion on books or papers of general interest which may be submitted for that purpose, contributors will please remember that this column is intended in the main for reviews of technical books dealing with the Engineering, Electrical, Shipbuilding, Iron and Steel, Mining, and Allied Industries. The address of the publisher and prices should be enclosed in all publications sent for review.

"ELECTRIC WAVES."

By H. M. Macdonald, M.A., F.R.S. Cambridge University Press. 200 pp. 10s.

THE object of this treatise, an Adams' prize essay, is to discuss the possibility of obtaining directly from Faraday's laws a consistent scheme for the representation of electric phenomena, and of applying the results to obtain the quantitative relations which exist in certain cases of the propagation of electrical effects. The fact that in certain cases the direct application of Faraday's laws gives without ambiguity results different from those which appear from the latter form of Maxwell's theory, led the writer to suspect that there must be some flaw in the process of reasoning by which this form of Maxwell's theory is deduced from Faraday's laws. This suggested the procedure adopted in the essay, to begin by applying Faraday's laws without the intervention of any dynamical theory to the different cases which can arise, and to examine whether the results obtained are consistent with observation. A satisfactory scheme having been developed in this way, a short account of Maxwell's procedure is given with a view to discovering the source of the discrepancy; and the result of examination is to show that the first form in which Maxwell presented his theory is a logical consequence of Faraday's laws, while the second form is not. The latter part of Mr. Macdonald's able essay is an application of the general theory to some of the problems that present themselves in connection with the propagation of electrical effects.

"LIGHT RAILWAY CONSTRUCTION."

By Richard M. Parkinson, Assoc.M.Inst.C.E. Longmans, Green and Co. 244 pp. 10s. 6d. net.

THE subject of light railway construction is a matter to which considerable attention has latterly been drawn. In America and on the Continent the value of these useful means of transport has been more practically recognised than in England, and their construction has been carried on under more favourable conditions. It was not until the year 1896 that the construction of light railways was authorised in this country by special Act of Parliament. British capitalists have not been slow to take advantage of the opportunity then offered, and the past few years have seen the construction of several new lines, and the flotation of many companies for the laying down of others. Mr. Parkinson's new work is intended as a book of reference for the use of engineers in practice and for the instruction of their pupils and assistants. That there was a need for such a text-book is undoubted, and the author, who appears to have a sound knowlege of his subject, is to be congratulated on its timely production.

He has entered into the details of light railway construction very carefully, almost every eventuality being considered. Eighty-four diagrams illustrate the volume, and there is much useful information to be found in the appendices.

"THE ELEMENTS OF MACHINE DESIGN. PART II."

By W. Cawthorne Unwin, F.R.S., M.Inst.C.E., M.Inst.Mech.E. New edition, revised and enlarged. Longmans, Green and Co. 428 pp., fcp. 8vo. 6s.

PROFESSOR Unwin's work forms one of Longman's "Text Books of Science" for the use of artizans and students in public and science schools. The first volume is concerned with general principles, fastenings, and transmissive machinery. Part II. deals chiefly with engine details, and is partly a collection of designs, data and rules, of use in the workshop and engineering drawing offices. It is, however, something more than a mere collection of facts, the reasons for different arrangements and proportions being freely discussed in connection with the examples given. Series of practical problems for engineering students form suitable exercises on the applications of principles demonstrated, and, on the whole, an endeavour has been made to give as clear and concise a survey of this important subject as possible. Text-books of this character were never more necessary than at the present time, when the number of engineering students and engineering schools is so rapidly increasing; and it is only by maintaining a high standard of excellence in text-books of technical instruction that the demand for efficiency in the training of the engineer can be adequately met. The present edition (which contains over 250 illustrations) has been largely rewritten, partly in view of more recent researches, but chiefly with the object of better adapting it as a reference book for draughtsmen as well as a text book for students.

"A TEXT-BOOK OF ASSAYING."

For the use of those connected with Mines. By C. and J. J. Beringer. Charles Griffin and Co., Ltd. Crown 8vo. 10s. 6d.

THIS valuable work is probably the most useful treatise on assaying available to the mining engineer. It deals in a clear and lucid manner with the various processes, and should prove invaluable both to the student and the practical man. It now appears in its eighth edition with slight alterations in the text.

"THE AMERICAN COTTON INDUSTRY."

By T. M. Young. Methuen and Co. 146 pp. 1s. 6d.

THE above volume represents the result of a tour of investigation made by the author amongst the cotton-spinning districts of the United States, and its contents were first published as a series of articles in the *Manchester Guardian*. At a time when American methods of manufacture are so prominently before the public, Mr. Young's book affords a valuable and timely insight into the organisation and working of this rising American industry. The results of his inquiry have, it may be said, been somewhat of a revelation to British cotton-spinners.

"APPLIED MECHANICS FOR BEGINNERS."

By J. Duncan, Wh.Ex., A.M.I.M.E. Macmillan and Co., Ltd. 324 pp.

THIS little volume is intended to provide students of engineering and allied constructive arts with a practical statement of the principles of mechanics essential to an intelligent interest in their occupations. The various principles are clearly elucidated and suitable exercises provided, together with a short course of laboratory work. There are also a number of half tone and line illustrations, a useful index, and answers to problems.

"INTERNATIONAL ENGINEERING CONGRESS (GLASGOW), 1901."

Report of Proceedings and abstract of the Papers read. William Asher, Glasgow. 406 pp.

THE above volume neatly summarises the results of the great congress on engineering held in Glasgow last year. The interesting, but somewhat lengthy, papers read are represented in a condensed form, convenient for ready reference; and the whole work should prove an indispensable addition to the library of the engineer.

NEW·CATALOGUES AND·TRADE PUBLICATIONS

These catalogues may be had free of charge on application to the firms issuing them. Please mention PAGE'S MAGAZINE when you write. Manufacturers of Engineering and Electrical Specialities, etc., etc., are invited to forward for review in this column copies of their catalogues, price lists, and circulars, as soon as issued.

Some Opinions on the Septic Tank System.—This is a second edition of a neat, illustrated booklet of 88 pages and cover, issued by the Septic Tank Syndicate, Ltd., of 7 and 8, Bedford Circus, Exeter. It is profusely illustrated by half-tone blocks from photographs of installations in all parts of the country, and also contains a short description of the system, together with many complimentary letters from city corporations, town and urban district councils, etc.

British Thomson-Houston Company, Ltd., Rugby.—Pamphlet No. 133. A further addition to this firm's exhaustive catalogue, dealing with a new twin carbon enclosed arc lamp, for single operation on high voltage continuous current circuits which, it is claimed, is quite as efficient as the long-arc multiple lamp, and gives a perfectly white light equal in quality to that from a standard five ampere 80-volt arc lamp.

R. Cundall and Sons, Ltd., Shipley.—This is a well-printed and illustrated booklet of 48 pages and cover, describing the "Cundall" Patent Oil Engines, which have been thoroughly tested, and are extensively used for driving machinery of almost every class, including electric lighting, stone and wood working, hoisting, pumping, printing, agricultural, and other kinds of machinery. Many letters of a highly complimentary nature have been received from users of this type of engine in all parts of the world.

Dudbridge Iron Works, Ltd., Stroud, Glos.—A well-designed and excellently-printed brochure of 32 pages and cover, containing some full-page illustrations from very fine half-tone blocks, portraying to great advantage the different types of "Dudbridge" Gas and Oil Engines which are manufactured by this firm. It appears that the greatly increased demand for these engines has necessitated an extension of the company's premises, and for this purpose new buildings have been erected and new machine tools of the most modern design have been laid down. The illustration on page 24 shows a new portable oil engine, the working parts of which are on a steel girder frame, provided with suitable travelling wheels and shafts. Another speciality manufactured by this firm is a fuel gas-producing plant for driving gas engines and for heating purposes. In this connection a useful table is given showing capacities, approximate space occupied, and gross weights of the various types of plants.

Wheeler Condenser and Engineering Company, Londoa.—This is a catalogue of 120 pages and cover, illustrating and describing many of this firm's principal specialities, including the Wheeler standard surface condenser, the Wheeler Admiralty surface condenser, the Wheeler feed-water heater, an improved evaporator, centrifugal pump, the "Barnard Wheeler" water-cooling towers, etc. The many illustrations of condensing water-cooling plants, installed by this firm in various parts of the world, are particularly interesting. The company is prepared to build pumps for special high duty service of any capacity required, and among other special work to its credit is the successful construction of a waterworks pump weighing 50,000 lbs., having a capacity of over 4,000,000 gallons per hour, and a 52-in. discharge.

Edward Chester and Co., Ltd., London.—The latest catalogue issued by this firm (No. 4) is a booklet of 64 pages and cover, well illustrated by half-tone and line blocks. It deals with their many specialities in mining machinery, including horizontal and vertical Corliss engines of various types, and there are some very useful tables giving powers of high speed condensing engines, circumferences and areas of circles, with capacities and surface of condensers, etc. There are also two or three draft specifications, which cannot fail to be of much service to prospective buyers of Corliss engines, both horizontal and vertical. The Bristol Recording Gauge supplied by this firm, automatically records the fluctuations of steam pressure upon a revolving chart, and appears to be a most useful instrument. It may be placed in the office or engine room, at any distance from the boilers or vessel in which the pressure is to be recorded. The capacity ranges from 15 to 1,000 lbs. per square inch.

The Anglo-Continental Machine Tool Company, London.—This firm—the successors to the "Richards Machine Tool Company," of Suffolk House, Laurence Pountney Hill, E.C.—have just issued an illustrated index and price-list describing their many specialities in machine tools, including planing machines of various sizes and types, boring, drilling, turning, and milling machines; also some American types of lathes in various sizes. At the end of the book appears a telegraphic code which foreign correspondents will find very useful.

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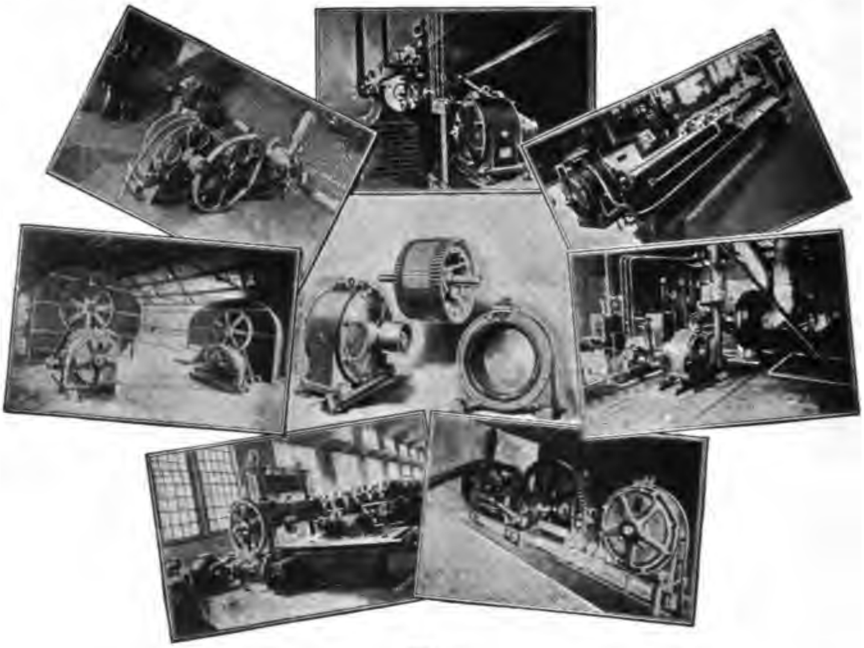

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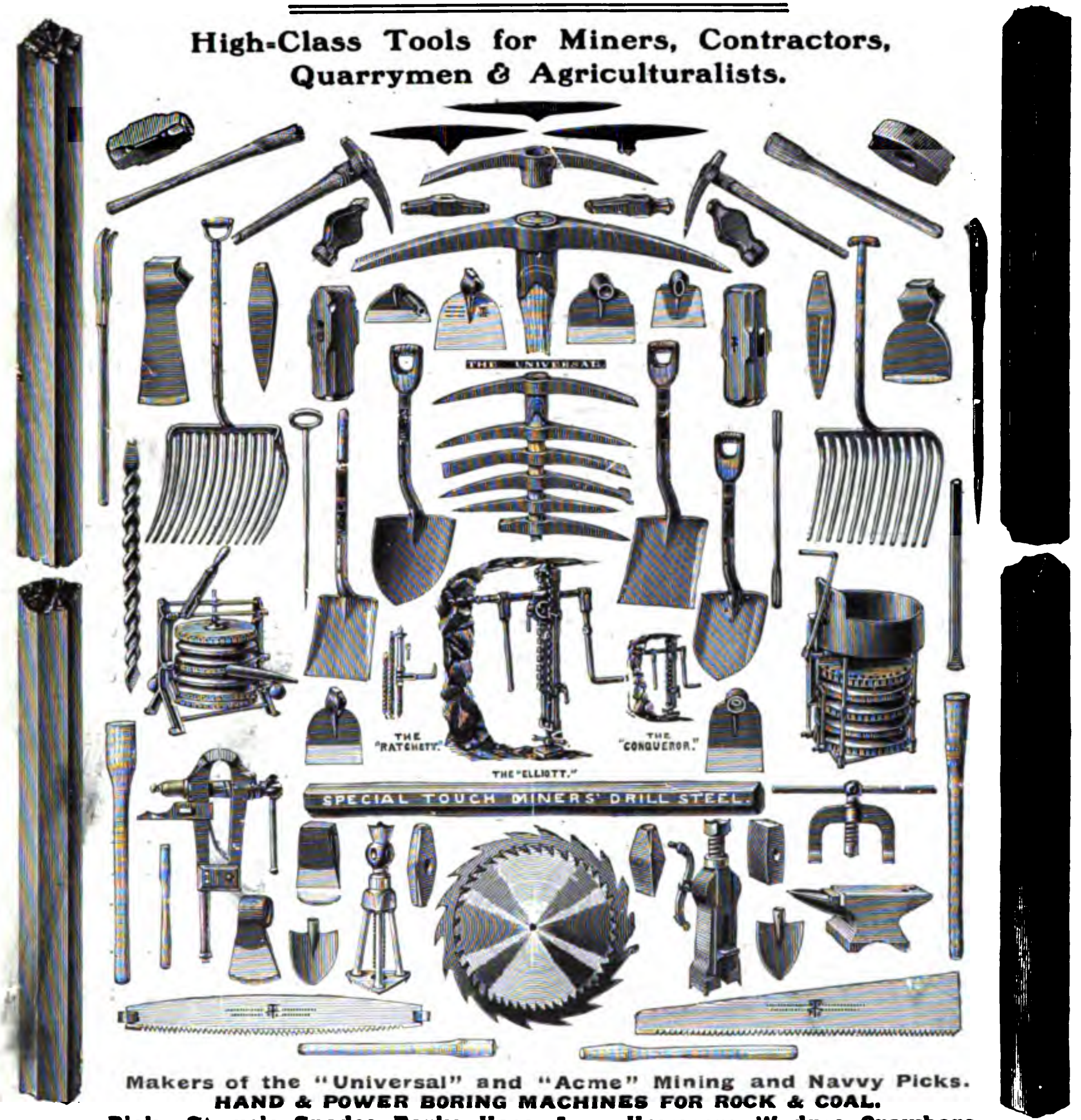
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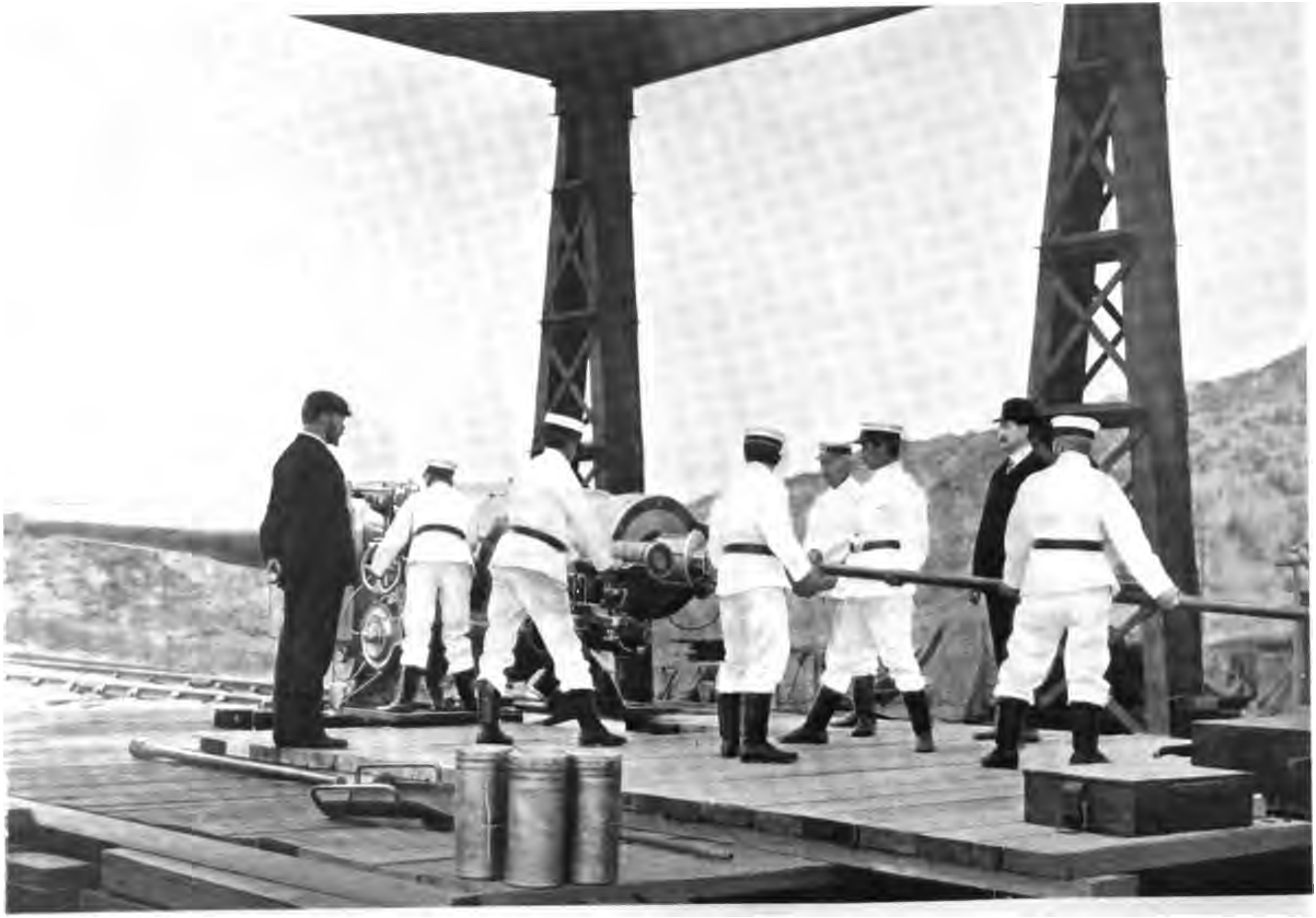
CONTENTS

No. 6. DECEMBER, 1902. Vol. I.

FIRING A 7·5 QUICK-FIRING GUN	. . . .	Frontispiece
THE ROYAL DOCKYARD AT PORTSMOUTH With Seven Illustrations.	W. Price . . .	611
THE COMMERCIAL DEVELOPMENT OF INVENTIONS	James Swinburne, President of the Institution of Electrical Engineers, M Inst.C.E., M.I.Mech E., &c.	619
THE TRAINING OF PROFESSIONAL ENGINEERS	Professor Goodman, M.Inst.C.E., M.I.Mech.E.	627
FORTHCOMING DEVELOPMENTS IN THE MARINE STEAM TURBINE With numerous Illustrations.	Herbert C. Fyfe . .	631
MILLING MACHINES.—VI. . . . Treats of Profiling Machines, in which outlines of irregular shape are produced by the aid of a pattern or former, similar in outline. Illustrated.	Joseph Horner . .	646
WORKSHOP PRACTICE . . . A Résumé of Machine Tools, Cranes, and Foundry Matters for the Month. With Illustrations.	. . . . . .	662
NOTES AND NEWS	. . . . . .	667
NAVAL NOTES . . . . Monthly Notes on Naval Progress in Construction and Armament.	N. I. D. . . .	673
THE "FUEL" VALUE OF TOWN REFUSE	E. C. de Segundo, A.M.Inst.C.E.	680
A STATISTICAL REVIEW OF BRITISH COAL AND IRON PRODUCTION	. . . . . .	686
LOCOMOTIVE ENGINEERING NOTES	. . . . .	691
BUSINESS SYSTEM AND ORGANISATION—IV. Cost-keeping. Illustrated.	D. N. Dunlop . . .	696
AMERICAN RÉSUMÉ . . .	. . . . . .	704
OUR MONTHLY RÉSUMÉ . .	The Editor . . .	709
NOTABLE BRITISH PAPERS OF THE MONTH	. . . . . .	715
REVIEW OF LEADING CONTINENTAL PAPERS	. . . . . .	721
BOOKS OF THE MONTH .	. . . . . .	726

The Editor does not hold himself responsible for opinions expressed by individual contributors, nor does he necessarily identify himself with their views.



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PAGE'S MAGAZINE

An Illustrated Technical Monthly, dealing with the Engineering, Electrical, Shipbuilding, Iron and Steel, Mining and Allied Industries.

VOL. I. LONDON, DECEMBER, 1902. No. 6.

RAT ISLAND, PORTSMOUTH—THE SUGGESTED COALING POINT.

THE ROYAL DOCKYARD AT PORTSMOUTH.

BY

W. PRICE.

In giving publicity to this article, the Editor would emphasise the fact, stated elsewhere, that he does not necessarily identify himself with the views of contributors.

A number of controversial points are raised, and some of the leading questions connected with dockyard administration are here presented as they appear to the casual observer. Next month the matter will be dealt with from an opposite point of view by a naval expert.—EDITOR.

IN view of the fact that the Royal dockyards cost the country millions every year, and are as necessary to the existence of the Navy as the Navy is to the existence of the Empire, it is astonishing that so little should be known about them by the nation, whose property they are.

A Royal dockyard is just a big engineering and shipbuilding establishment that is prevented by red tape from becoming as efficient at all points as the best of private yards are. It differs, too, from the latter in that the picturesque impress of the Navy is visible in every part of it. Of the various Royal dockyards, that at Portsmouth is the most important, though it is closely followed by Devonport and Chatham. From the days of Alfred the Great, Portsmouth has figured in naval history, but the present dockyard only dates back as far as Tudor times. In the reign of Henry VIII. the yard covered just eight acres; it now spreads over about 300 acres, and there is a likelihood of further extensions in the near future.

As one would expect in a place that has been centuries in developing, the ancient and

OVERCROWDING IN PORTSMOUTH DOCKYARD.

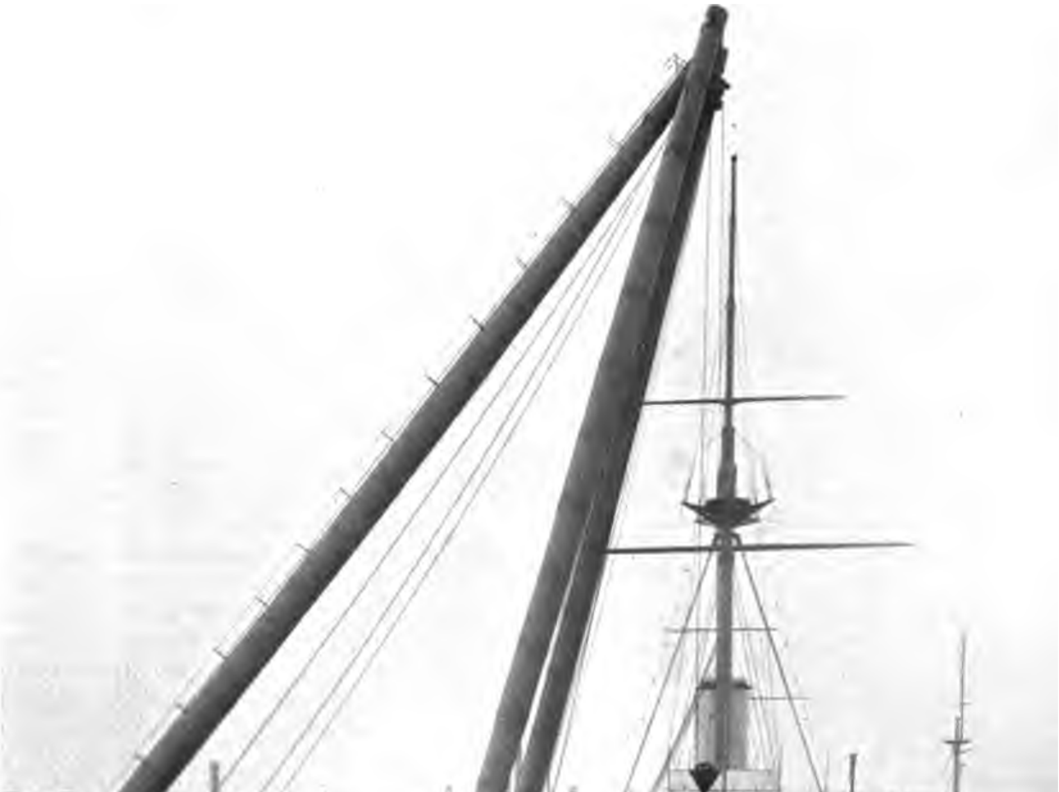
Old vessels awaiting purchase.

the modern exist cheek by jowl. In one place you can see dry docks, closed with gates and floored with stout oaken slabs, and a little further away some of the finest dry docks in the world. Altogether the yard contains 17 docks. No. 1 dates from 1340, and is 253 ft. 9 in. long, and 57 ft. 1 in. deep. Nos. 14 and 15, the most modern in the yard, are each 565 ft. 6 in. long, one of them is 94 ft., the other 82 ft. deep. These were built in order to accommodate the big four-funnelled cruisers that are now becoming so numerous in our fleet. Two other docks are also being considerably lengthened, because our warships have outgrown the accommodation provided for them. There are also six basins, having an aggregate area of 69½ acres, the largest basin being 22 acres in extent. Berthing room for a great many ships is provided alongside the jetties and in the harbour, and yet the dockyard is frequently overcrowded.

INADEQUATE ENGINEERING PLANT.

A good deal of space is given up to storehouses and workshops, and from an engineering point of view the latter form the most important section of the establishment. Even to-day the Admiralty does not always adopt a receptive attitude towards new ideas, and in the past its conservatism has often been adamantine. Proposed changes were regarded with disfavour because they would have been innovations; not because they were unnecessary. The Naval service, both ashore and afloat, suffered as a consequence. In time a more progressive generation came along, and wrought useful changes in the fleet; but still the dockyards were neglected. And even now in the workshops at Portsmouth and other similar establishments, there is to be found plant that no enterprising shipbuilder would think of retaining.

Taken as a whole, the engineering plant is somewhat antiquated and insufficient : it cannot cope with the demands made upon the establishment. It is a strange commentary upon Admiralty methods that our chief Naval dockyard is so poorly equipped with engineering machinery that the engines of a small cruiser cannot be built there without seriously interfering with the repairing and refitting work on other vessels. Yet that is



H.M.S. "GOOD HOPE" UNDER THE GREAT STEAM DERRICKS AT PORTSMOUTH DOCKYARD.

They have been tested to 150 tons, and are said to be the largest in the world.

THE FLEET RESERVE AT PORTSMOUTH DOCKYARD.

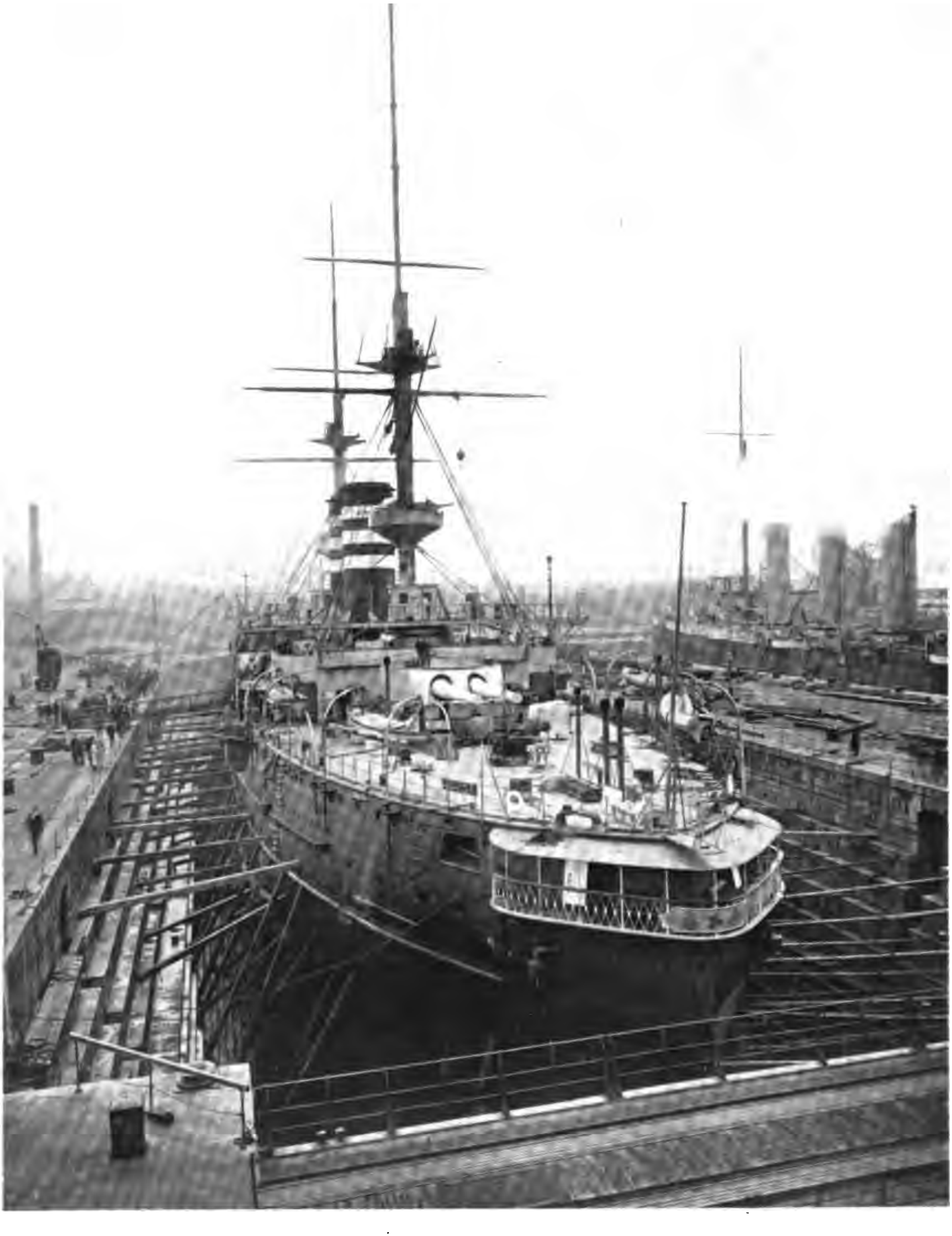
These vessels are being disposed of by the Admiralty in order to make room for new ones.

how matters stand at present, as was proved by the delay in constructing the engines of H.M.S. *Pandora*, which are of only 7,000 i.h.p.

The Admiralty officials know the incapacity of the dockyards in this particular so well that the engines of our new warships are nearly all made by private contractors, even when the hulls are dockyard built. Undoubtedly there is much to be said in favour of allotting to private firms a good share of Government work; but that does not excuse the engineering deficiencies of our premier Naval yard. This establishment, like the ships attached to it, for manning and maintenance purposes, should be kept in a condition that would ensure its being in the highest possible state of efficiency if a war broke out. The yard, however, cannot be said to be kept up to this standard. Its engineering plant is insufficient for peace requirements, and it would be impossible to adequately meet the strenuous demands that war would make upon it. Such a condition of affairs, if allowed to continue, could, without exaggeration, be asserted to constitute a grave national danger.

It is only fair to the Admiralty to say that a certain quantity of new machinery has been purchased. But the shops have not been restocked with it to the extent they ought to have been' or to an extent that will secure as much efficiency as could be obtained in the space at present allotted to engineering plant.

A new steam factory is to be erected at an estimated cost of £188,000; but how much of this is to be spent on bricks and mortar and how much on machinery is not apparent. The building of a new workshop in a Royal dockyard is not always a move towards greater efficiency in the plant. Within the past few years a new boiler-making shop has been constructed at Portsmouth; but a good deal of old machinery was used in its equipment. It is to be hoped that this policy of building new stabling for old horses is not to be followed in the case of the new steam factory. In the estimates for the current financial year £7,000 is allowed towards the cost of the factory. This may, perhaps, mean that towards the end of the year the site will be laid out and the foundations excavated. Whether the remaining £181,000 will be provided next year, will depend upon whether the Admiralty wants the money for other purposes or not.



THE JAPANESE BATTLESHIP "MIKASA."

BASINS, ETC., PORTSMOUTH DOCKYARD, SHOWING SHIPS PREPARING FOR COMMISSION.

WHY IMPROVEMENTS ARE DELAYED.

One cause of the engineering deficiencies of Portsmouth dockyard is that the Navy and the Naval establishments are controlled mainly by sailors (the sea Lords of the Admiralty), who are prone to consider dockyard equipment as of secondary importance to the multiplication of ships. Another cause is the procrastinating methods of the Admiralty. If a private firm decides that it needs new machinery, it straightway gets it. But such business-like directness is impossible in the dockyards. First, the Admiralty has to be brought to recognise that the new machine is wanted; then the various departments concerned have to take the matter into consideration. Eventually the thing gets so far that it is put into the next year's estimates; and then the peculiar system of allocating expenditure operates to produce further delay. Instead of the required article being purchased outright, a certain sum of money is allowed towards the cost of it; a part of the work is done, and the remainder carried over till the next financial year. The block mills at Portsmouth afford a good illustration of the necessity for the renewal of much of the dockyard plant. The machinery in these mills was designed by the elder Brunel in 1801. At that time its construction was a big jump forward; but machinery a century old in design can hardly be considered as suitable for a modern industrial establishment. Some of the smithery appliances are also obsolete, and some of the docks are still emptied by chain pumps that have done service for many years past. Although Portsmouth is the principal Naval dockyard, it possesses only one building slip. This has been lengthened so that a vessel 500 ft. long can be laid down upon it.

SOME UP-TO-DATE APPLIANCES.

A step in the right direction, however, has latterly been made by the erection of a new smithery, and, more especially, in the laying down of a pneumatic tool plant for rivetting and drilling alongside the slip. These tools, which are of American pattern, are a most valuable addition to the dockyard, where all rivetting and drilling has hitherto been done by hand. Another important improvement is the introduction of what is reputed to be the most powerful set of steam derricks in the world.

VIEW IN PORTSMOUTH DOCKYARD.

Ships getting ready for sea, and torpedo-boats in dock.

These were erected about a year ago by Messrs. Cowans, Sheldon and Co., Ltd., of Carlisle, and have been tested to 150 tons. The illustration of these derricks is doubly interesting, as the ship lying beneath them is H.M.S. *Good Hope*, which has been requisitioned for Mr. Chamberlain's journey to South Africa. For the working of the capstans, the sliding caissons and some of the cranes, compressed air is generated at a central station and carried all over the yard. To a considerable extent the dockyard is built upon mudland that was reclaimed by convicts. But the wearers of the broad arrow are no longer employed as dockyard labourers, and the prison that housed them has been turned into electrical workshops.

ADMINISTRATION AND ORGANISATION.

So much for the engineering aspect of the dockyard; now a word as to administration. There are some 10,000 workmen employed at Portsmouth, and the wages bill is upwards of £14,000 weekly. This is exclusive of officials' salaries and the pay of the not inconsiderable number of men from the Naval Depôt who are employed about the yard in one capacity or another—mainly upon ships. The Commander-in-Chief, who is a full Admiral, has control over the ships commissioned and ready for commission, the Naval Depôt and the gunnery and torpedo schools. The dockyard proper is in the charge of a Rear-Admiral, denominated the Admiral-Superintendent, who receives in pay and allowances £1,883 per year, and is furnished with a residence. He also has a professional adviser called a civil assistant. This official, who is an ex-Chief Constructor, draws a salary of £1,000 a year. Other heads of departments—are the Chief Constructor, whose maximum salary is £850 a year; the Chief Engineer, who receives £750 a year, and is a naval officer; and the Director of Works, a Royal Engineer officer, who is paid £1,000 a year. The Staff Captain and King's Harbour-master, and captains of the dockyard and fleet reserves are not, strictly speaking, dockyard officials, though their duties lie within the yard and they have official residences there. Admiral-Superintendents are appointed for three years. Usually they are men who have spent the greater part of their lives at sea, and consequently their training has not perhaps been of the kind that best fits a man to guide a big industrial concern. At present, however, Portsmouth possesses an Admiral-Superintendent who has good qualifications for his post. But past experience of this and other yards has demonstrated that though a man may be an excellent fleet-commander, he may not be suitably qualified for the post of Admiral-Superintendent. It can scarcely be expected that a system that often plumps round men into square holes can produce uniformly successful results. The best man to manage a shipyard is unquestionably the one who is specially fitted, by his training, for the post. A man who has spent the greater part of his life in learning seamanship, gunnery, etc., can hardly possess many qualifications for managing a big shore establishment. The complexities of dockyard organisation are difficult to understand. But there are, however, some good points about it, one of the best of which is

THE SYSTEM OF TRAINING MECHANICS.

The majority of people will, no doubt, be surprised to learn that there exists in the Royal dockyards a system of technical education that might advantageously be taken as a model by the country generally. No Cockerton judgments can interfere with it, and it has for years past given splendid results. Apprentices pass into the yard by examination, and, after getting in, have to attend the dockyard school for a period of three years. They thus get practical knowledge in the shops and theoretical instruction in the classes. In order to encourage the lads, the highest boys at the yearly examinations are made either engineer students at Keyham College or students of naval construction, as the case may be.

Sir E. J. Reed, Sir William White, Mr. Philip Watts, nearly all the Chief Constructors in the Royal dockyards, and many men who hold important positions under private firms, began life as apprentice boys at Portsmouth and other Royal dockyards, and owe their start in life to the teaching of the dockyard schools. This educational system furnishes the yards with highly skilled mechanics; and in order that the Government may have a hold upon them, a certain proportion of the men are "established"—that is, they become civil servants, and, as such, are entitled to pensions at the age of sixty. A good many of them must perforce remain at their tools, as opportunities for promotion are limited, and the only hope they have of earning extra money is by qualifying as divers. A good deal of diving work is done in the dockyards. Divers are wanted every time a ship is docked, and also for repairs to caissons, etc.

COALING FACILITIES.

One of the basins at Portsmouth is given up to ships in the A Division of the Fleet Reserve, vessels that are ready for commissioning. Close by these is the coaling point, which should store about 20,000 tons of coal. Usually a much larger quantity is laid there, and within recent years fires caused by overcrowding the storage space have given some trouble. To prevent a recurrence of these, and to provide more liberally for the demands of the ships, plans were prepared for the provision of a big coaling depôt. Rat Island, in Portsmouth Harbour, which is now used as a parade ground by the boys of H.M. training ship *St. Vincent*, was suggested as a suitable spot, but owing to the difficulty of finding good foundations for the piling, it seems probable that this scheme may be abandoned. In this event, some other must be devised in place of it, for the present coaling depôt is not only too small, but is also insufficiently equipped with transporting appliances. Only one big ship at a time can fill her bunkers alongside it.

In Portsmouth Harbour are many acres of mudbanks. The work of removing these in order to provide moorings for more ships is being steadily proceeded with. Every year some £5,300 is spent upon the dredging operations. But unless the rate of progress is accelerated, many years must elapse before the area of deep water is greatly extended. However, valuable anchorage space has been added to the port, which can now afford a haven for a considerable fleet.

THE COMMERCIAL DEVELOPMENT OF INVENTIONS.

BY

JAMES SWINBURNE,

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ARGUMENT.—Conventionality and hatred of novelty—one reason for want of enterprise in England. Different ways of financing an invention. Finance in early stages. The syndicate and its troubles. Inertia and want of enterprise of moneyed men. The limited company and its evils. A typical inventor and his difficulties. His own industry will not have him. Outsiders ignorant. He gets up a syndicate. He gives up most of his interest. The syndicate gets short of money. Forming a large company. The ways of promoters. Indecision. Waste of time and money. Final flotation. Outrageous capital. Incompetent directors. Final catastrophe. What is wanted.

THE more unpractical of the political economists assume that a good thing will at once displace a bad one; and that a different manufacture, as good as an old product or better, and at the same time cheaper, will replace it forthwith. Such a theory as this is held only by people with a profound ignorance of human nature. We have all a great deal of the savage in us still, and one of the strongest characteristics of the savage is his hatred of the labour of adopting anything new. People dislike anything that involves bodily exertion, but they generally hate anything that involves thinking, and more especially anything like decision. Conventionality and custom are merely devices for saving people the trouble of thinking or deciding. In order to save us the trouble of deciding for ourselves, it is beneficently settled for us that we must wear clothes of a particular shape and colour, that our hats—in London, at any rate—must be cylinders of paste-board covered with the excretions of insects; that we must have open, smoky fires with a shelf over each, bearing three, five, or seven jars, or an even number of jars and a clock, that we shall eat off discs of silicate of alumina, and not off wood or metal; that we shall expose the tender legs and arms of babies to the weather; that we shall sleep half the day and sit up half the night; and so on through ninety-nine out of a hundred of the petty details of our existence. All this is to save us the pain of decision. In so far as it means economy of decision, so that we are more able to decide in other cases that come up, conventionality is a good thing; but to the extent that it saves decision altogether, it is merely keeping up our savage character. Extreme conventionality is conspicuous among savages, and among lower types generally. The schoolboy, being undeveloped, is much more conventional than the man, and woe betide the luckless youth who tries to do anything new or original at a public school. Next come women, and next to them comes the average man. Most men hate to have to arrive at any decision on anything, and loathe anything new that involves any change of mental attitude. The ordinary magistrate's hatred of the bicycle ten years ago, and the persecution of the motorist to-day, are due to savagery. The local opposition to electrical tramways, the objections raised to iron steamships and breech-loading guns in the Navy, and to anything modern in the Army, and generally to all improvements that involve change, are due to the same survival of savage instinct.

The unfortunate inventor is thus tremendously handicapped from the very beginning. Everything seems to be against him in the early stages, when he is working out his crude idea, and the whole world is against him as soon as he tries to develop it commercially. The man of unapplied science has difficulty in getting a new theory understood, or a new discovery realised; but he has mainly to depend on other men of unapplied science for his reputation. At the very worst, if he can but publish a paper, he is secure, as it is only a matter of time. If he does not belong to the right scientific clique he may have his papers rejected by learned societies, or buried, as Waterston's was, or may meet with opposition, as in the case of young Helmholtz; but he only has to wait, and if he is right he gets his full reward. He has not to persuade capitalists or the public that his views are right. An inventor, on the other hand, must not only work out his theory, or make his discovery, which is as far as his colleague goes; but he has to work out details, get his invention into a practical shape, and get it taken up by the public. If he fails in any one of these matters, he reaps neither credit nor anything more solid; he might much better have left the whole thing alone.

WHY BRAINS AND MONEY DO NOT GO TOGETHER.

It has been said that some people have money and other people have brains. The obvious retort is that if the other people have brains they ought to get the money too. The proverb looks like the outcome of envy, and at first sight seems to have no foundation in fact. But it may be true all the same, and there may be a very good reason for it. Life is so short that it is very difficult for a poor man to become very rich, at any rate in this country. But the struggle which the poor man has to undertake excites the growth of his mental faculties, and though it may not give him any more new brains, it sharpens and trains what he has. The great man in nearly all walks of life has had a hard struggle when young, and he not only succeeds because he is a great man, but he is a great man largely because he has had to struggle in early years. But the unfortunate inventor, unless his invention is of some very peculiar kind, has to be financed, and is thus dependent on moneyed people for his start, and people who talk glibly about making fortunes by inventions have very little idea of the difficulties in the way of the inventor who wants capital.

We may consider the different types of people who finance inventions, and try and see the causes of the want of enterprise. We are told by the newspapers that the country is in a bad way because we are now devoid of enterprise. This is ascribed to many causes. Want of technical education is one reason given, and there may be a good deal in it. This cry is, however, also largely due to the technical science teacher, who wants to glorify his office; and until our technical school teachers are technologists with practical knowledge we shall not get any technical teaching, and while they are mere unpractical bookmen, who insist on trying to teach technology which they do not understand, instead of unapplied science, which they might more easily study, we must do without the teaching of first principles too. But there is something far deeper than any matter of technical education: there is a complete want of enterprise. Is it not because money, and therefore control of industry, is largely in the hands of the sons of the people who made it? A man in the busy part of last century, owing to a plucky struggle as a young fellow, develops a large manufacturing business. In due time his sons come into it. They have had an easy time as boys, and are only able to carry the business on. It takes little to carry on an established business; it will in a way go on, and even increase, of itself. If the sons work at their father's business they do so in a rather ineffectual way, but they are more likely to take no interest in it whatever. In England snobbery does us great harm industrially. We have still the idea that a gentleman is a man with no occupation. The ambition of the son of the cotton spinner or iron-master is to belong to the county. He therefore buys a house away from the town where his work is, and hunts and shoots, becomes a country magistrate, and believes it will be a bad time for the country when the good old sporting country gentleman dies out. Such a man as this puts any money he has to spar into various limited liability companies, which last a year or two and then retire to the *ewigkeit*. We will deal with limited companies presently.

THE LIMITED COMPANY.

Another type of man entirely is the City financier. He is keen enough in a way; but he knows nothing of industry, and he is only concerned with floating limited companies and selling out quickly. All he wants is to get shares which are rising and to sell them at a higher value. He does not concern himself in the least with industrial success.

The limited liability company was intended as a means by which all sorts of big enterprises might be taken up by small investors without danger. It was intended as a great blessing, but its results are quite the reverse. Most people who are wise do not live up to their incomes, and they want to invest the difference. There is no difficulty in finding a safe investment at low interest, but people think they can do better by investing in limited companies with glowing prospectuses, and as a rule they lose their money. But a man who loses his money in this way does not realise that he was a fool. He says: "Ah, well, it was only a flutter; better luck next time."

The limited company system is a colossal machine for getting rid of the savings of the nation in the most unsatisfactory way. Of course, many large undertakings have to be limited as to liability, but are otherwise worked on the same lines as private concerns. Their shares may be good investments, but they are generally bought by people who know, and do not go to the outsider. It never seems to occur to the ordinary speculator that if the shares in something he knows nothing about were valuable they would be bought by the people who do know about it, and they are only offered to outsiders because insiders will not have them. Investors in companies act like sheep. Some acquaintance makes some money out of a company because an even bigger fool buys the shares from him at an increased value. All his friends regard him as a sort of financial genius, and he becomes a bell-wether, and eventually, if cunning, he may develop into a director.

There are fashions in investment too. At one time Australian mines were the proper thing. It was the custom in Australia to float anything of little value in England. On one occasion a cable message from this country ran: "Stake out some mine directly; sold it for hundred thousand." The gold mine is the most popular, however; probably the average investor thinks gold is of necessity more valuable than copper, lead, or zinc. We are not, however, concerned with limited companies generally—that would be a very large subject. We need only discuss their relation to the inventor who needs financial assistance to develop a new industry.

THE INVENTOR'S POSITION.

We may take an imaginary inventor with a typical invention, and describe his experiences. We imagine the inventor to be a young and unknown man, who is well up in the technology of his subject, and we will assume he has discovered a new way of making white-lead. We will assume not only that he thinks he has made this discovery, but that he has actually discovered a way of making a pigment from lead which is cheaper than white-lead and better as to colour, covering power, and working with oil. He has made a few ounces with great difficulty at home, so he puts his sample in his pocket, and asks to see the proprietor of a white-lead works. He cannot get past a junior clerk, who takes his sample bottle and leaves it on a mantelpiece with little bottles of oil and other samples left by travellers. The oldest bottles have half an inch of dust on them, the others less in proportion. In a month he comes back, and sees his bottle where it was put, and finds nothing has been done. Probably he never gets past the junior clerk at all. But he tries many white-lead makers, and eventually gets to the proprietor. He is generally away shooting, or in the country, and only comes to the works once a month, and can spare very few minutes. He says: "I don't believe in artificial white-lead. It's been tried before, and is no use." This seems to him a conclusive argument. The inventor urges that he has studied the whole subject and knows exactly what has been done and what has not, and that his white-lead is all right. "But it is artificial, is it not? And if so, I tell you artificial white-lead has been tried before and won't do. Good-bye." This is as far as he is likely to get with a manufacturer. If he is very persistent the proprietor may say: "Well, I'll give your sample to my chemist to try; I am not a technical man myself." The chemist probably analyses it, and has a preconceived theory that the goodness of white-lead varies directly or inversely as the hydrate present, it does not matter which, or he examines it with an oil-immersion objective, and if the particles are not of the shape he is accustomed to he will have none of it. He, therefore, reports against a new white-lead with an abnormal composition. He would report against it anyhow, because he does not really know, and if he reported a bad thing good he would get into difficulties, while in the reverse case nothing happens. He is prejudiced against anything new in any case, and sitting on someone else makes him feel superior. Moreover, if he let another man with technical knowledge into the works he might be ousted. However good the invention, it has no chance with the works chemist, or his analogue in other businesses.

It is hardly necessary to say that the white-lead maker and the inventor are entirely imaginary. The only whitel-ead maker I have known is remarkably keen about any invention or improvement that he can get hold of. White-lead is merely taken as a typical case.

It may be said that this view of a typical manufacturer is absurd; the proprietor of a works is far too eager and keen to let a good chance slip by. It must be remembered that he is not himself technical; that he has many supposed inventions brought him, and is quite unable to judge of them. In addition, taking up a new thing involves changes, and he would have to decide things, and there is nothing such a type of man hates more than having to decide anything.

The inventor therefore tries the paint merchants. They do not believe in artificial white-lead. One enterprising man may go so far as to say: "Send us a hundredweight, and we'll let our painters try it." Of course, the inventor cannot make a hundredweight. If he did, the painter would guess it was something new and report against it at once. No workman can stand anything new. Even if it were ever so much better he would oppose it.

The wretched inventor has thus no chance of getting his idea taken up by the proper people, that is to say, those already in the industry. He therefore turns to outsiders.

THE INVENTOR TRIES OUTSIDE HELP.

The first thing he wants is a few hundred pounds to try his invention on a larger scale. He cannot get at any big capitalist, because he is unknown and the affair appears too small. He has already wasted perhaps a year trying to get a hearing in the trade. He now hunts up various people, and at last gets the ear of someone, who is asked to put up £500 for a half share in the venture. He views the matter favourably, but cannot decide on such an important matter quickly. He has to be humoured. After six months of anxiety and disappointment, the inventor again gets an interview. "Oh, well, I thought you knew I'm taking up another matter, and I can't go into your affair now. Your scheme only offered a final profit of 30 per cent. on the capital; I have come across a young genius whose invention—a cheap way of making celluloid—promises much more than that. In the words of the claim it is: Treating shrimps with acetone, filtering off the shrimps, and evaporating the filtrate to recover the acetone, leaving the celluloid in blocks, substantially as described." "Have you ever tried that invention or consulted an expert?" "My inventor is a young genius; he knows it will work without trying it. I did ask an expert and he said shrimps' cases are not celluloid; but as he could not say what else they were, I don't believe he knows anything about the matter, and is prejudiced. My inventor does not know anything about theory, and is therefore independent of it. Celluloid is worth several shillings a pound, and the by-products being perfectly shelled are more valuable than the original shrimps, and will be sold for potting. Why, we can make a fortune from the by-products alone!" Who does not know the inventor with by-products!

The capitalist's relation with the engineer expert is also very curious. As a rule, a man will carefully avoid consulting an expert before investing. If he does come, he does not want your real opinion, he wants his own backed up. If you advise against the investment he is very much annoyed, and probably invests all the same. He thinks you are prejudiced, or that you are afraid to run the risk of recommending anything, in case of failure. On the other hand, if you recommend the investment, and make a mistake in so doing, and the investor loses his money, he does not blame you. He treats you as a sort of brother in adversity, and recommends you to other people, and your practice thrives.

THE INVENTOR FORMS A SYNDICATE.

We will suppose, however, that in some way or another the inventor has got a few people to back him up, and has formed a syndicate with £1,000 available to try his invention on a larger scale. He has probably spent from one to two years in doing this, and has had to give away most of his interest in the invention, and has got much less money than he thinks necessary for the work. He probably under-estimates the cost anyhow, as even people with great experience of experimental work generally under-estimate the expense. The result is that the money is finished before the experiments are completed. The men who have put in the money will not put in any more. Each put in a hundred with the idea of getting ten thousand. He will let his hundred take its chance, but on no condition will he put in more. The inventor has given away so much of his own interest that he has no further inducement to offer. Nine good inventions out of ten are lost at this point. No new men will come in, for they say: " If your own people won't find you the money, there must be something wrong." The idea of getting the process examined technically is out of the question.

But we will suppose this particular inventor to be more fortunate than most, and that he has succeeded in getting as much money as necessary. It is probably a larger sum than need be, because his financial friends will have taken months and months to consider the question of finding more money, so that the works have been going on in an inefficient and expensive way. But in spite of that we will suppose he has spent ten thousand or so on his works, and has made several tons of very good white-lead, but the works being purely experimental, and very small, cannot be run on a paying scale. Now comes the most difficult time of all. He has to get a company formed large enough to make white-lead commercially on a paying scale. This needs, let us say, some £50,000 available in cash.

I must again repeat that I have no particular individual inventor in my eye. The case is typical only. The only white-lead inventor I know about did not get so far as this. An investor, as a rule, not only wants good terms, but he will not come in unless he gets better terms than all the previous investors. The inventor, as far as I understand the matter, not only gave away his whole interest, but in his anxiety gave away some of it twice by mistake. The result is a deadlock, and he is doing other work. His white-lead may be very good indeed—I do not know—but he, and probably no one else, will ever get anything out of it.

EXPERIENCE WITH FINANCIERS.

The inventor's financial friends are probably not in the swim as company promoters. They are small capitalists who have gone as far as they care to, and now expect other people to sow and grow their harvest for them. He approaches a financial house. With great difficulty he gets at one of the partners, who knows nothing about white-lead, and cares less, for he has nothing to do with the final commercial results. If he can form a company which the public will take up, so that he gets his money at once, he will be willing to do so. He must have special terms himself. This means that the syndicate gets practically nothing, and the inventor a small share of that. He will discuss it with his financial friends. After a few months, during which the inventor worries the financier at intervals, the financier says he cannot take the matter up. The inventor tries another house. After much delay he sees one of the principals, who says: " No. I lost money over a process once, so I am not going in for any more processes. If you had a mine, or a wireless telephone, or a submarine passenger steamer, or something striking, I could deal with you."

By this time his process will have been " hawked about," as it is called. This is one of the most mysterious disqualifications. If a financier hears of anything from more than one quarter, he condemns it off-hand on the ground that it has been hawked about. It is very difficult to see why. Every financier wants special terms, and unless he can get in on what he considers better terms than other financiers, he will not go in. If other financiers have had the opportunity of going in, he has no special chance. Neither will he set his judgment up against that of the earlier financier. As a matter of fact, neither has any judgment to set up, for they know nothing technically, and merely estimate the chance of shoving a company on the public. Meantime the syndicate is getting into greater and greater difficulties owing to the delay. The City men say the Money Market is down, or South Africans are doing something eccentric. At this stage some people probably offer to take the matter up, and want a free option for, say, two months. They do nothing at all, but hope that in two months the syndicate will be glad to accept anything. At the end of the two months they offer a loan of £500 for a four-fifths share or something equivalent. The financiers' delay is no doubt generally due to pure indecision and want of grit, but it is also sometimes tinged with questionable integrity.

It will generally be found that the financial circles really are circles. A white-lead process will always come round eventually to one or two men who act as a sort of bell-wethers. They have made money out of some other process perhaps. When they invest, the sheep all follow, so the whole success of the process really depends on them. They probably do not know the difference between white-lead and black-lead, but they have the reputation of "knowing a good thing when they see it."

At this stage the inventor and his friends have probably spent several years and several thousand pounds. They have a process which is good and valuable, and worth a great deal of money; but they are totally unable to get it considered seriously. Probably no expert has examined it on behalf of any investors, because they have not got so far as that. The whole thing stands condemned because it promised no ridiculous profits, and because those directly interested in it are too inert and unenterprising, while the City man regards it as gone stale. What generally happens at this stage is that the whole thing collapses, and the patents are allowed to drop. Then the process is taken up in Germany or America, without any payment of royalty, and worked commercially, and the papers say we want protection, and the science teachers, who never invented anything, say we want technical education.

HE GETS A COMPANY FORMED.

But suppose they really induce a financial house to form a company. The procedure is complicated and mysterious, and only a specialist in company formation could say exactly what happens. First we will suppose £50,000 in cash is needed to put up the works. An ordinary person would say that if the syndicate were to have a half share the capital should be £100,000, half of this being paper. Nothing of the sort! The capital will be about £300,000, and the syndicate will not get half, nor anything like it, and the inventor may get what chemists call a "trace." Out of the £300,000 probably half will be issued for cash. Where it all goes to is a mystery to the outsider, but there are various calls. In the first place the promoter will not go on unless the shares are underwritten. The underwriters want a good deal for their risk, for if the issue is not taken up their money is locked up for some years. It does not matter whether the process is good or the company eventually pays. They must either have their money locked up and unavailable, or they must sell out low. Even if the invention is good and everything right they are dependent entirely on the fancies of a perfectly ignorant and sheep-like investing public. If one paper runs the issue down, all the sheep will turn aside, and the underwriters will be left with all the shares. The prospectus is generally issued and the dates fixed so that the technical papers, which are weeklies, cannot criticise. It is impossible to bribe technical papers. Of course, it is absolutely impossible to bribe or affect financial papers in any sort of way too. But people who watch the relations of the interior opinions to prospectus advertisements, and people who buy large numbers of copies of financial papers containing accounts of their public meetings, and people who have to give away shares to gentlemen whose part in the proceedings is vague, sometimes get a false impression as to the immaculateness of our noble financial press. If the new company has plenty of promoters' shares it is a coincidence that it will be praised up as an investment in the right quarters, and has nothing to fear. But with the technical press it is different. It cares nothing for prospectus advertisements, and is run by a class of people who acquire any shares they ever want by purchase for cash. The promoters thus fear the technical press. The technical press considers, not whether the shares are going to a premium the day after to-morrow, but whether the company is financially sound, and can eventually pay dividends. The promoter of the sound company is just as much afraid of the technical press as any other promoter. How does he know his company is sound ? That has nothing to do with him, and is outside his ken altogether. He has therefore to risk the technical papers. Sometimes the technical papers condemn a good thing, as a technical editor has to be omniscient, and has to form an opinion with few data, and he is more likely to condemn a good thing than to praise a bad one. Be that as it may, the lists are always arranged to close on Thursday, while the technical papers come out on Friday.

In order to make the issue go down, the promoters not only need underwriters, they need directors. A board of incompetent amateurs is necessary, preferably with a few titled names and some retired soldiers. Then the brokers require a big fee for the appearance of their names. A consulting chemist is needed, and a report from some entirely non-technical professor with a string of letters after his name is published. He has probably never been inside a white-lead works, and has no idea of the costs of manufacture, on which everthing depends. Then the patents have to be submitted to counsel. Counsel says they are valid, but does not say whether they really cover the process, or whether they can be perfectly easily circumvented. In this case we will suppose the patents are valid, and protect the proprietors. Then the company is finally launched on the guileless public, and thousands of people in all walks of life, with all possible varieties of ignorance about white-lead, take shares, and the peers and retired generals proceed to wreck the whole affair by gross and idiotic mismanagement, and in three years the inventor, with a ruined reputation, seeks a minor appointment in a works where they use the good old Dutch process.

WHAT IS WANTED.

What is wanted is a strong financial concern which will develop inventions on terms that are fair to both parties. Such a concern should never put a large proportion of its capital into any one thing, and it should be advised by competent specialists as to both technical and financial questions. The experts should be technologists, not unpractical people, and should hold shares in the concern. Such a house could make terms with an inventor at any stage of the development of his invention. At first the inventor has generally inflated ideas, but they always cool down in contact with financial difficulties. Such a concern as this, managed on business lines by really technical business people, would develop enormous industries, and make an immense amount of money ; but it would have to be managed by people who had enterprise, were not led like sheep by City opinion, decided quickly, dealt honourably, and were technical business men.

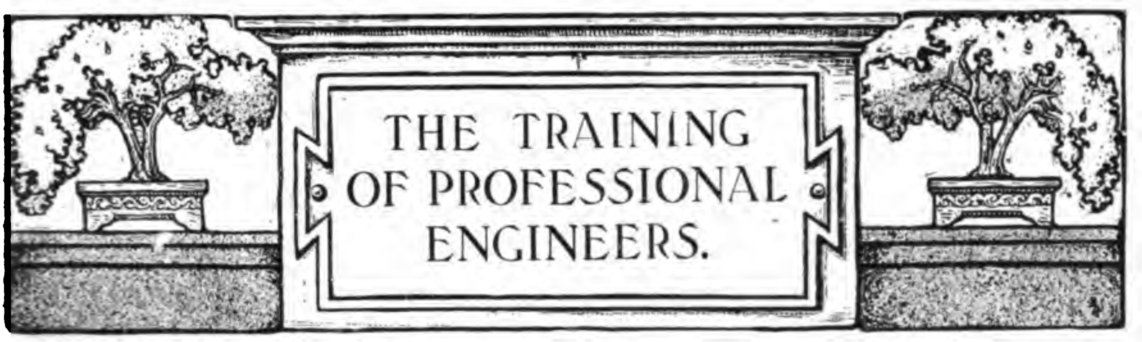
PROFESSOR JOHN GOODMAN, M.Inst.C.E., M.I.Mech.E.,

Professor of Engineering, Yorkshire College, Leeds.

PROFESSOR GOODMAN, unlike so many who hold similar positions, had a very thorough practical engineering training. He served two years at fitting and turning in the Progress Iron Works, Bassingbourn, Cambs., and three and a half years at erecting, turning, fitting, pattern-making, and foundry work in the Globe Works, Northampton. As assistant to the late Mr. Stroudley, in the locomotive works of the L.B. and S.C. Railway, at Brighton, he carried out a large number of tests on the friction of bearings, the strength of crank shafts and axles ; also the testing of locomotives. While there he obtained a Whitworth Scholarship, and afterwards went to the University College, London, to study the scientific side of engineering. After further experience as assistant to Professor Kennedy, F.R.S., in his Westminster office, he took a temporary post on the staff of *Engineering*. Following that appointment, he was for two years chief assistant to Mr. W. H. Stanger, of the Broadway Testing Works, Westminster.

Photo by Jas. Bacon and Sons.]

In the autumn of 1899 he was appointed the Professor of Engineering in the Yorkshire College, Leeds, a post which he still holds. During his tenure of the chair, the engineering department has flourished in every respect. The numbers have increased threefold, and the laboratories have been enlarged, and much new plant has been added ; in fact, it is now one of the most successful and best-equipped engineering colleges in the country. He is the author of several papers on friction, for which he was awarded a Miller Prize and a Miller Scholarship by the Institution of Civil Engineers. He is also the author of many short papers, and his well-known book, "Mechanics Applied to Engineering," is used in many English and American colleges.



THE TRAINING OF PROFESSIONAL ENGINEERS.

BY

PROFESSOR JOHN GOODMAN, M.INST.C.E.

As Professor of Engineering at the Yorkshire College, Leeds, the author has had exceptional facilities for watching the careers of some hundreds of young engineers, and his very practical remarks should prove of considerable interest to those who contemplate embarking upon engineering as a profession.—EDITOR.

THAT a young professional engineer requires a special training to fit him for his future work probably none will deny; but as to what course that training should take there appears to be a great diversity of opinion. As one who has advised and carefully watched the careers of some hundreds of young engineers, the writer trusts that his opinions upon this matter may afford some guide to those who contemplate the starting of their sons upon an engineering career.

The writer has always made a great point of keeping in touch with his former pupils, in order to watch their progress in the profession, and to enable him to study carefully the effect that their technical training has had upon them. This friendly intercourse between a professor and his former pupils cannot be other than mutually beneficial: and, as far as the writer is concerned, he has, moreover, found it to be one of the most pleasant experiences of an interesting and absorbing profession.

The head of a large and important engineering department is frequently called upon to advise parents and schoolmasters as to the wisdom, or otherwise, of certain lads taking up engineering as a profession. In such cases the writer usually puts a few test questions in order to discover, if possible, whether the lad has a reasonable chance of success at engineering, such questions being somewhat on the following lines: (1) Is the youth tolerably robust, and if not, has a medical man been consulted as to the probability of his being able to stand the rough practical work that is absolutely essential to every engineer? If this cannot be satisfactorily answered, a decided opinion is expressed that engineering should not be chosen by him as a profession, for if an earnest youth makes an honest attempt to do his duty in the works it will make considerable demands on his physical strength. (2) Is he really keen about engineering, and does he intend to stick to it in spite of hard, dirty work, and possibly a large amount of drudgery for some years to come, and is he determined to succeed at all costs? If a youth is not quite sure whether he will like engineering or not, and wants to know if he may wear gloves in the shops and whether he need start work before breakfast, etc., etc., it is a sure and unmistakable sign that he is not made of the sort of stuff that engineers are made of, and the sooner he decides upon a trade or profession that does not demand manly qualities the better for all parties concerned. (3) Has he done reasonably well at school, especially in mathematics and mechanics, and is he of a studious turn of mind?

In the writer's opinion a youth cannot hope for success in the higher branches of the profession unless this last question can be answered satisfactorily.

As regards his school training, he ought to get a thoroughly good general education, such as is given in most of our public schools. It is probably not well to specialise in the school training to any great extent, but in the higher forms modern languages may advantageously be taken in preference to Latin and Greek. In mathematics, as a minimum, he should be familiar with the first three books of Euclid, or the subjects thereof, as taught in some modern text-book on geometry; also arithmetic and algebra up to quadratic equations. A knowledge of elementary mechanics, physics, and chemistry is desirable, also freehand and geometrical drawing.

The school workshops in many public schools do valuable work by giving youths a good idea of the use of tools; but, of course, they cannot possibly give a sufficient training to enable them to dispense with the practical training in engineering works.

In the case of those youths who intend to take up a university degree course, higher standards than those mentioned above are necessary.

AGE AT LEAVING SCHOOL.

It is impossible to draw a hard and fast line as to when a youth intending to become an engineer should leave school, but it should certainly not be under sixteen, and only in rare instances should it be over eighteen.

ENGINEERING TRAINING.

In the case of civil engineering students, we believe that the college training may be taken immediately after leaving school. But, in the case of mechanical and electrical students, there is a great difference of opinion as to the best order of training; the chief point of contention being—whether the works should precede the college training, or *vice versâ*. We think it will be well to state the arguments advanced by both sides. They are:—

In Favour of the Works Training Preceding the College Training.	In Favour of the College Training Preceding the Works Training.
Students who have not obtained some practical experience in works cannot take full advantage of the college course, on account of their ignorance of machinery and manufacturing processes. The works training is to a large extent a question of acquiring manipulative skill; hence it is better for such training to be taken while young, say, at sixteen or seventeen, rather than three or four years later.	Youths make more rapid progress in practical work after having taken a college course than when they enter works straight from school. The college training teaches them how to learn and how to observe; consequently, when they get into work they pick up the practical side of the work much more rapidly than the novice who comes straight from school.
It is much more distasteful to a student to commence the inevitable rough and dirty work in the workshops at, say, twenty years of age than at sixteen.	If a youth leaves the works in which he has spent, say, four or five years, in order to go to college, he breaks his connection with the firm just at a time when he is most valuable. He thereby gets out of touch with his firm, and may lose the chance of promotion with them; and, moreover, it rarely happens that a young fellow of, say, one or two-and-twenty cares to throw up remunerative work for two or three years in order to go to college—the result being that he misses his college training altogether.
The scientific side of engineering is the more difficult to acquire; hence it is better that it should be taken up when the student is somewhat matured, rather than when he is fresh from school.	A youth coming fresh from school is in the habit of acquiring knowledge and has all his mathematical and elementary science fresh in his mind; consequently, he has a far better chance of making headway at college than the youth who has allowed his school-work to get rusty.
Youths often take up engineering as a mere fancy, and do not discover that they are unsuited for it until they have to "rough it" somewhat in works; hence, if they go into works first they much more quickly come to a decision, and consequently waste less time than if a college course intervenes.	
Many proprietors of works and heads of firms object to taking youths into their works as pupils or apprentices at the age when most students leave college.	

The writer's experience leads him to believe that there is much force in many of the arguments advanced by both sides; therefore, after very careful consideration, he has come to the conclusion that in the case of mechanical and electrical engineers, the best course to adopt is a compromise between the two.

COURSE OF TRAINING RECOMMENDED.

After receiving a good education, it is recommended that (1) a youth should be sent to some small general engineering works, where he is more likely to get a useful experience than in a larger establishment, for about twelve or eighteen months; (2) he should take either a two or a three years' course of instruction in a college, and during this time he should pass the qualifying examination for admission to the Institution of Civil Engineers; (3) he should go into some larger engineering works where he can specialise in some particular branch for a period of not less than two years; (4) he should go into the drawing office for at least one year. And, if possible, he should visit, or, better, spend a year or two in engineering works in the United States, where he will be able to earn sufficient to keep him and will gain most valuable experience. Such a course of training will thus take from six to seven years, which in some instances may be more time than many parents can afford to give their sons. In such cases, the expense of the college course may be materially reduced by scholarships; but this, of course, entirely depends upon the ability and diligence of the student. Then, again, if youths do well, they will nearly always receive some remuneration during the stages 3 and 4 mentioned above.

It should, however, always be borne in mind that the more thorough the training the higher will be the position ultimately attained, of course, assuming suitable material to work upon.

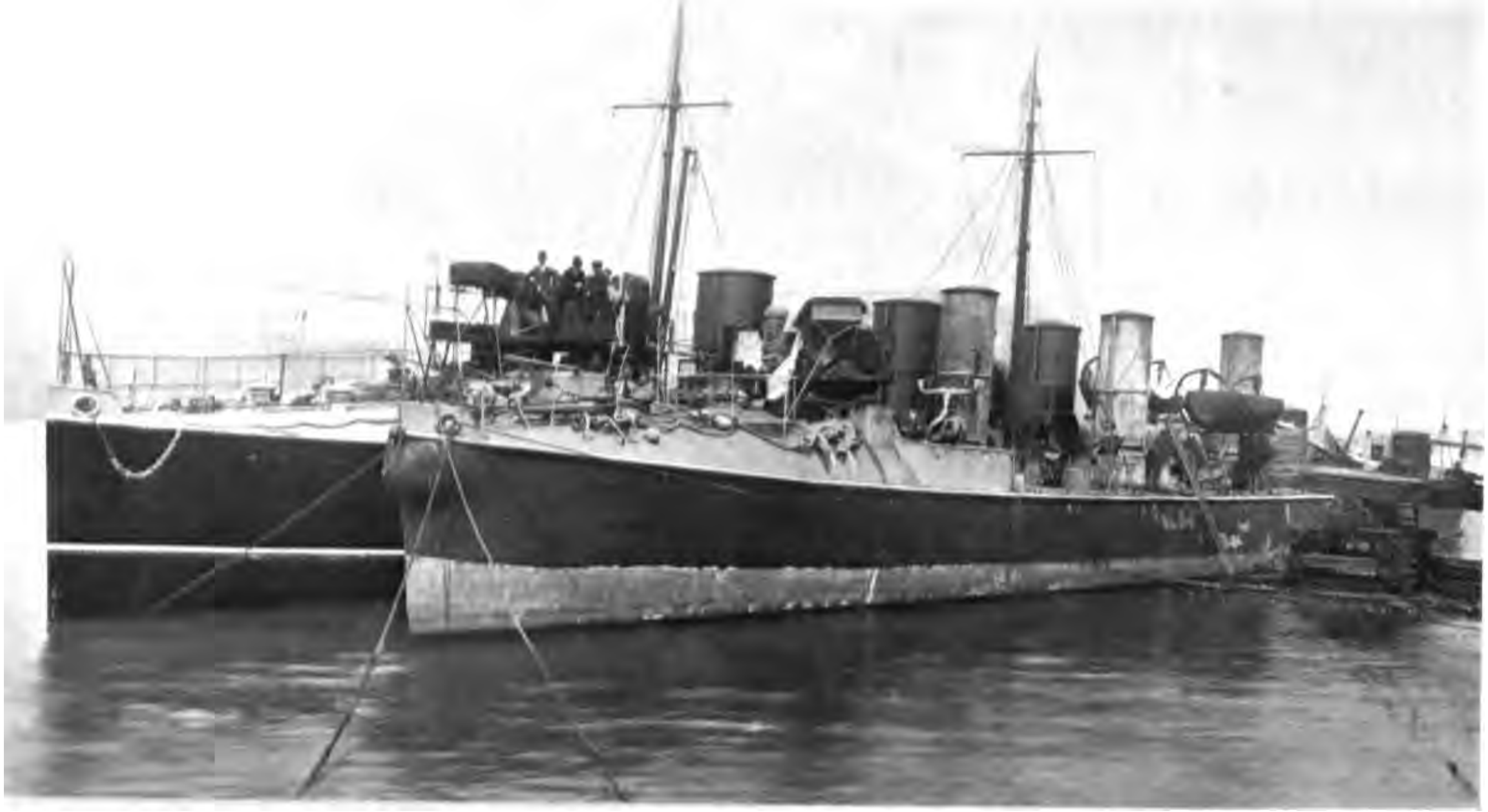
WHILE IN WORKS.

The writer would urge parents to put pressure on their sons to keep the regular and full shop hours, and not to allow them to commence work after breakfast: if a youth is not willing to make this sacrifice, he does not possess the necessary "grit" to make an engineer.

In order that a student may not allow his school work to get rusty, it is advisable that he should attend evening classes at a college for, say, two evenings a week, in such subjects as mathematics, mechanics, or drawing; but it is not recommended that more time than this should be devoted to evening study.

NECESSITY FOR WORKS TRAINING.

Parents often send their sons to institutions on account of the so-called "practical" instruction in shop processes which is given in their workshops, under the delusion that such a course of instruction will give a lad all the practical experience that he requires, and that he will thereby be saved the "dirty" work in engineering works. This, however, is a deplorable blunder, and if persisted in the lad will sooner or later find himself hopelessly incompetent to hold any important position as an engineer. The writer has seen so many instances of failure of young men who, although otherwise promising, imagined that they acquired sufficient practical knowledge of engineering when they were in the school and college workshops, but when they got out into the world were found to be sadly incompetent from a practical point of view, that he feels he cannot too strongly advise parents to avoid the mistake of fostering the idea that there is any such "royal road" to engineering. The fault does not lie with such workshops, but in the idea that they alone can give a sufficient practical training. The writer's experience, however, leads him to believe that the experimental work done in college engineering laboratories is of the greatest possible value to engineers, and that the college laboratory can do what cannot be done in the works, and that the works can do what cannot be done in a laboratory; both are regarded as indispensable, but each should do that which it is able to do thoroughly, and not spoil both by attempting to combine them in one and the same place.



TORPEDO-BOAT DESTROYERS—A CONTRAST.

H.M.S. *Havock*, the earliest destroyer (in foreground), and the new turbine vessel, H.M.S. *Velox* (behind).

COLONEL McCALMONT'S STEAM YACHT "TARANTULA."

FORTHCOMING DEVELOPMENTS IN THE MARINE STEAM TURBINE.

BY

HERBERT C. FYFE.

At the present moment the British Government is the only nation in the world that possesses a turbine-propelled war-vessel. The new torpedo-boat destroyer *Velox* was purchased by the Admiralty a few weeks ago, and has proved itself to be the fastest destroyer afloat. We are enabled, by the courtesy of the Parsons Marine Steam Turbine Company, of Wallsend-on-Tyne, to reproduce here some photographs of this and other vessels fitted with this form of turbine—which is the invention of the Hon. C. A. Parsons, a brother of the Earl of Rosse.—EDITOR.

THE marine steam turbine may be expected to be developed along the following lines:—

1. In war ships.
2. In passenger steamers.
3. In pleasure yachts.

It may be convenient to consider these in the order mentioned.

STEAM TURBINES IN THE ROYAL NAVY.

In his "Statement Explanatory of the Navy Estimates, 1902-03," the Earl of Selborne made the following reference to turbine men-of-war :—

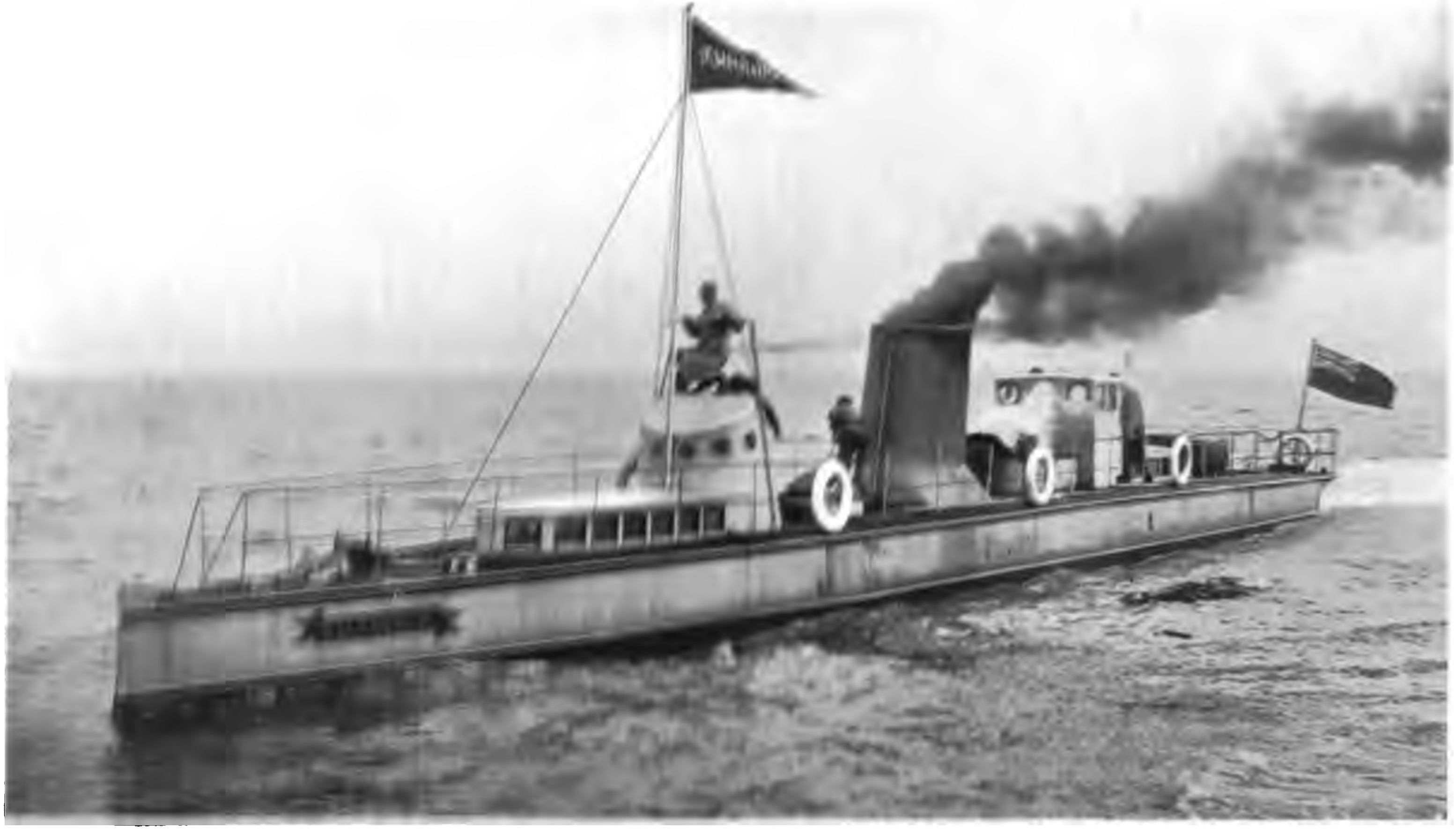
> The country has had to deplore the wrecks of H.M.S. *Viper* and *Cobra* during the past year, accompanied in the latter case by a lamentable loss of life. One result has been for the present to put a stop to our experiments with the turbine system of machinery, but the Board are negotiating for a renewal of the experiment in two more destroyers, and in one third-class cruiser.

In addition to the recently purchased *Velox*, the Admiralty will shortly possess another destroyer fitted with the marine steam turbine. It will be named the *Eden*, and has also been ordered from the Parsons Marine Steam Turbine Company. The hull is being constructed by Messrs. Hawthorn and Leslie, who were also responsible for the hull of H.M.S. *Velox*.

The third-class cruiser to be fitted with turbine machinery is H.M.S. *Amethyst*, one of two provided for in the Navy Estimates of 1901-02. The other, H.M.S. *Topaze*, will be fitted with reciprocating machinery of the ordinary type, and it will thus be possible to compare their speeds, coal consumption, economy, etc.

The French Government are believed to be experimenting with a view to determining the advisability of fitting some of the vessels of the French Navy with turbine engines, but so far as the writer is aware they have not up to the present purchased any ships so fitted.

H.M.S. *Velox* differs radically in constructive details from the *Turbinia*, the *Viper*, and the



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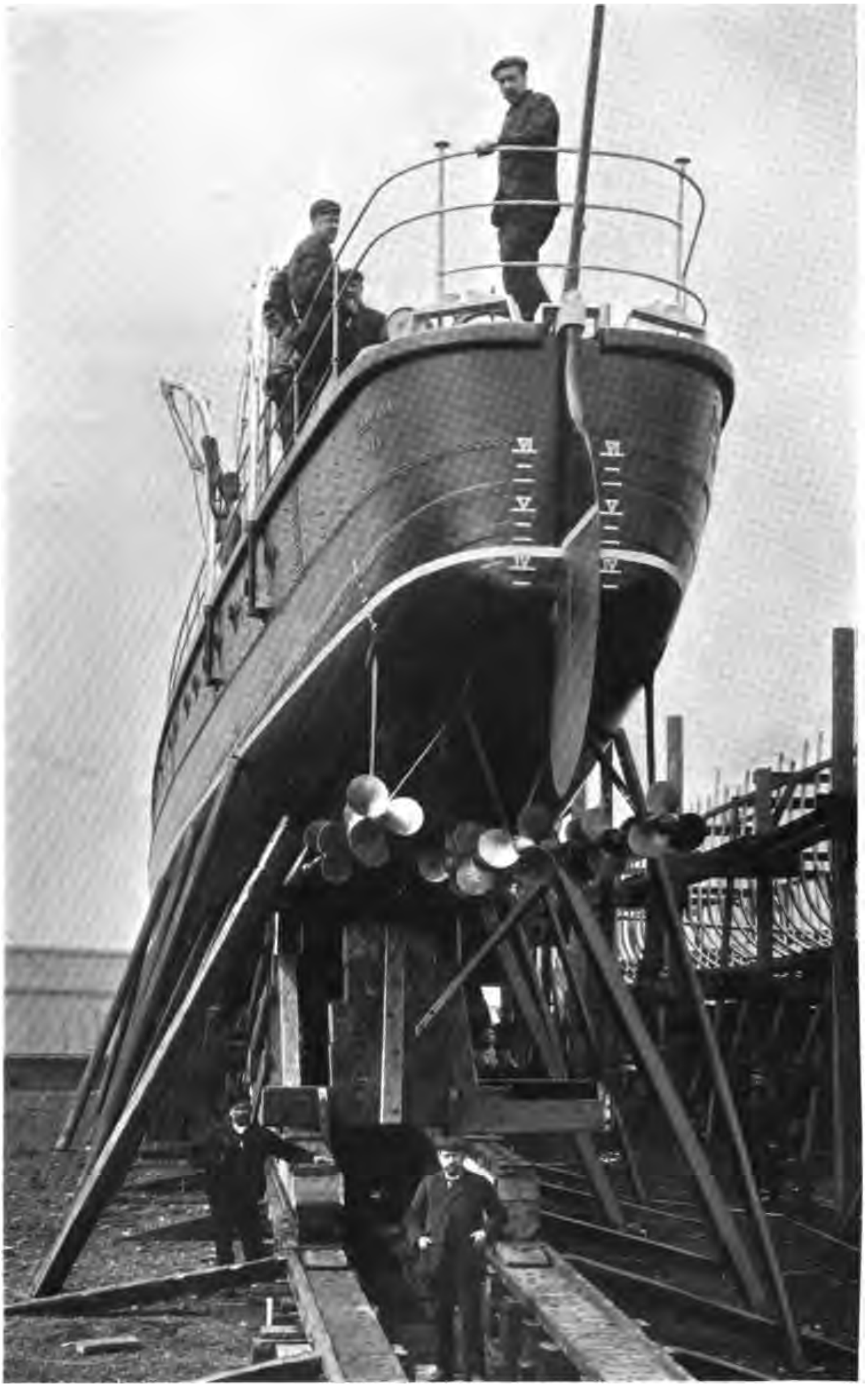
THE EXPERIMENTAL [illegible], "TURBINIA," STEAMING [illegible] KNOTS.



THE STEAM YACHT "TARANTULA."

By permission of the British Mutoscope and Biograph Co., Ltd.]

H.M. TORPEDO-BOAT DESTROYER "VIPER" STEAMING AT FULL SPEED.

Cobra. The *Turbinia*, the first vessel to be fitted with the marine steam turbine, was merely an experimental craft. She was 100 ft. in length, 9 ft. beam, 3 ft. draught of hull, and 44 tons displacement. She was fitted with turbine engines of 2,000 actual h.p., and reached a speed of 34½ knots.

In 1898 the Parsons Marine Steam Turbine Company contracted with the Admiralty for a 31-knot torpedo-boat destroyer, the *Viper*, which was to be of the same dimensions as the usual 30-knot vessels of this class, viz., 210 ft. in length, 21 ft. beam, and about 370 tons displacement, but with machinery of much greater power than was usual in vessels of this size. At the same time they contracted with Sir W. G. Armstrong, Whitworth and Co., for machinery for one of their torpedo-boat destroyers, the *Cobra*.

In his statement (dated 3rd March, 1898) for 1898-99, the First Lord of the Admiralty said that an order had just been placed for an experimental vessel, in which the steam turbine would be substituted for the ordinary reciprocating type of machinery in order to test the applicability of the system to torpedo vessels of exceptionally high speed.

The *Viper* was built by Messrs. Hawthorn, Leslie and Co., at Hebburn-on-Tyne, and was launched on September 6th, 1899. In his statement, dated February 17th, 1900, Viscount Goschen (then Mr. Goschen) said that the contract speed was 31 knots, but it was anticipated that a considerably higher speed would be attained; on preliminary trials (for short periods) speeds of about 35 knots had been reached. It was hoped that the vessel would soon be ready for her official trials, and when these were completed it was proposed to make exhaustive experiments with her, as great importance was then attached to this novel system of propulsion.

The *Viper* was 210 ft. long, 21 ft. beam, 12 ft. 9 in. deep, and her displacement was 350 tons. Her indicated h.p. was 16,000.

There were four propeller-shafts and two propellers on each, making eight in all, the revolutions being about 1,200 per minute.

In exterior appearance the *Viper* did not materially differ from the ordinary torpedo-

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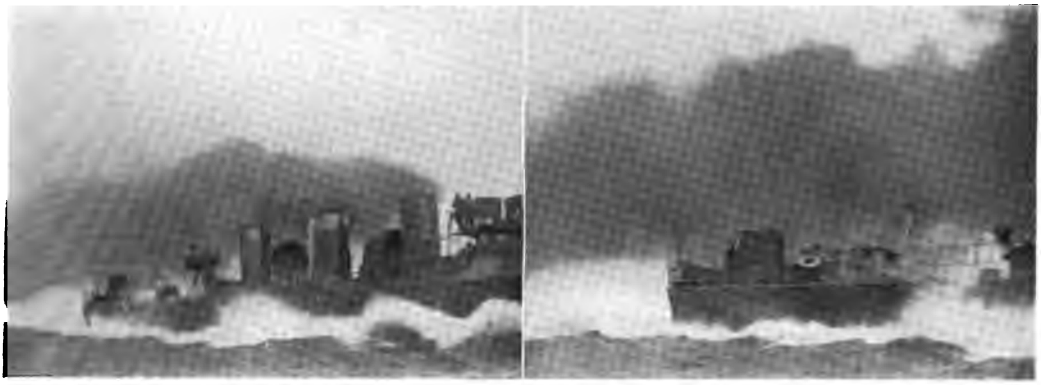


By permission of the British Mutoscope and Biograph Co., Ltd.]
H.M. TORPEDO-BOAT DESTROYER "VIPER" STEAMING AT FULL SPEED.

boat destroyer, except that her funnels were of much greater diameter; but down below the difference was at once manifest.

THE ENGINES OF THE "VIPER."

The interest in the vessel, as an engineer has remarked, is centred in the engine-room.

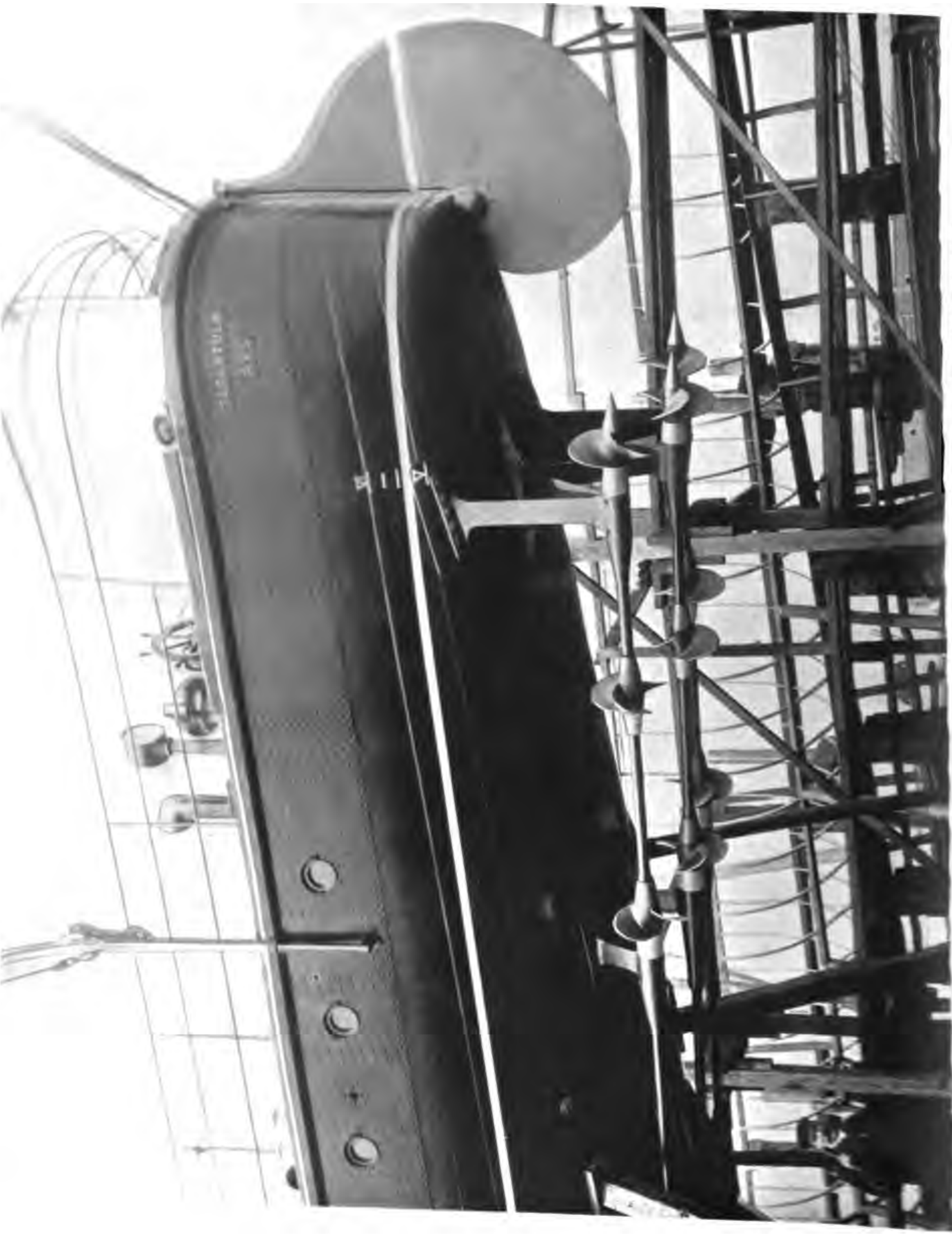
Here one meets with something quite different to the familiar double row of twin-screw engines, with their four cylinders, between which is the passage from end to end. In place of this, one descends on to a platform stretching right athwart ships, where are the large stop valves which control the flow of steam to the turbines, by which alone the engines are manœuvred; for there is naturally no valve motion, or, for that matter, no engine valves, nor any reversing gear. Beneath the platform is placed a good half of the engine, that is to say, the part which corresponds to the high-pressure cylinders of an ordinary compound engine. These turbines are, in fact, quite invisible, being stowed away under the floor, and need no attention whether running or standing. A little further aft are to be seen in the bottom of the vessel the larger low-pressure turbines, but the most conspicuous features are the large cylindrical condensers which, with their pipes and attachments, occupy the larger part of the room—a fact that will give an idea of the saving in useful space gained by the steam turbine.

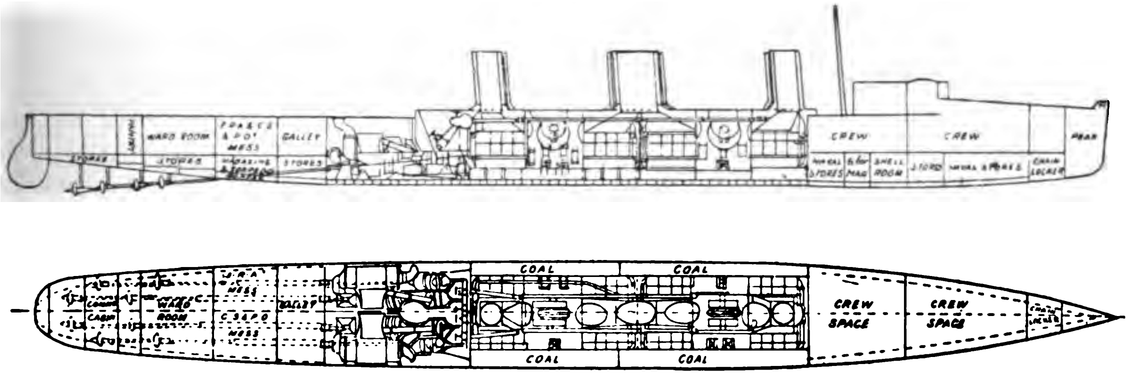
The turbine engines of the *Viper* were similar to those of the *Turbinia*, but were in duplicate, consisting of two distinct sets of engines on each side of the vessel. There were four screw shafts in all, acting independently of each other, the two on each side being driven by one high and one low pressure turbine respectively, of about equal power. The two low-pressure turbines drove the two inner shafts, and to each a small reversing turbine was also permanently coupled and revolved idly with them when going ahead.

Each shaft carried two propellers; thus the *Viper* was driven through the water by eight screws. The *Turbinia*, it will be remembered, had nine screws and three shafts.

The machinery on each side of the vessel was identical. The steam from the boilers was admitted directly through a regulating valve to the high-pressure turbine, driving one shaft; it then passed to the adjacent low-pressure turbine, driving its shaft independently; thence it flowed to the condenser, and both the shafts then drove the vessel ahead; the reversing turbine revolved with the low-pressure shaft, and being permanently connected with the vacuum of the condenser, no appreciable resistance was offered to its motion under these conditions. To go astern the head steam-valve was closed and the stern steam-valve opened, admitting the steam from the boiler to the reversing turbine and reversing the direction of rotation of the inner screw shaft.

The official trials of the *Viper* took place on May 4th, 1900. The best pair of runs gave 34·67 knots; a 60-ton load was carried, and the





ARRANGEMENT OF MACHINERY IN H.M. TORPEDO-BOAT DESTROYER "VIPER."

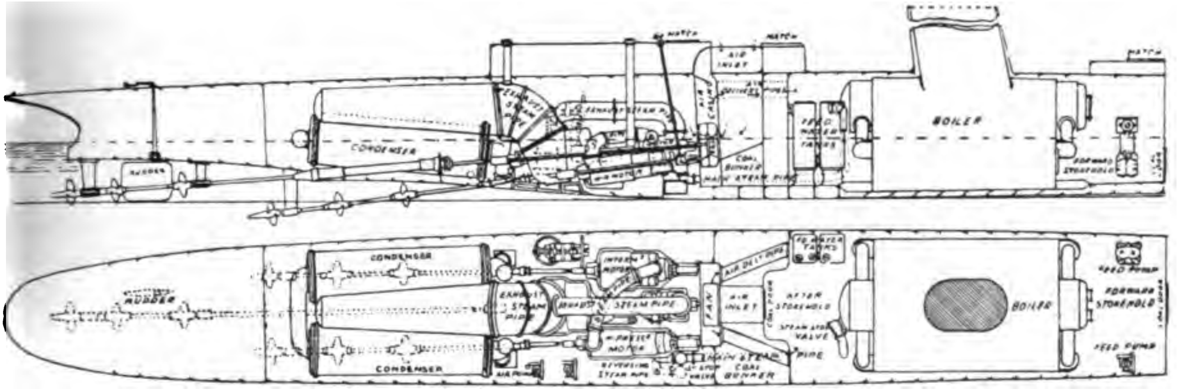
displacement at trial draught was 370 tons. The boat had been in the water some time awaiting her trials, and with a "scrubbed" bottom would have done better; the wind and rough weather were also against high speed.

In July, 1900, the *Viper* underwent one hour's full-power trial off the mouth of the Tyne over the same measured mile, and attained the remarkable speed of 37·113 knots, equal to 43 land miles an hour.

The load carried on the last occasion was above 10 tons in excess of the Admiralty requirements for 30-knot destroyers. The propellers revolved at the high rate of 1,180 per minute; unusually short times were required to work up to full speed, and throughout the trial the machinery worked with the utmost smoothness, and practically no vibration was experienced in any part of the vessel.

H.M.S. "COBRA."

The *Cobra* was laid down in the spring of 1899, and was built by Sir W. G. Armstrong, Whitworth and Co. Like the *Viper* she was fitted with turbine engines by the Parsons Marine Turbine Company. Her length was 223 ft., beam 20·5 ft., displacement 325 tons, and draught 8·2 ft. of water. The preliminary letter naming the conditions of purchase was dated March, 1900. She was supplied with one 12-pounder and five 6-pounder quick-firing guns, and two single training torpedo tubes for 18-in. torpedoes. Her complement was 68 officers and men, and her coal capacity 85 tons. She was fitted with Yarrow water-tube boilers, and her contract speed with an i.h.p. of 11,500 was 35·8 knots. She was launched on June 28th, 1899, and in December, 1899, was offered to the Admiralty. After a lengthened survey by the officers, she was accepted in May, 1900, on the understanding that certain alterations, chiefly strengthening the upper deck to bring her into line with the most recent Admiralty practice, would be made. These were at once carried out, and the vessel was purchased by the Admiralty.



ARRANGEMENT OF MACHINERY FOR "TURBINIA."

Photo by West and Co.]

H.M. TORPEDO-BOAT DESTROYER "TURBINIA" STEAMING 35 KNOTS.

The *Cobra* made her first sea-trial on July 15th, 1899. She had twelve trials, including the Admiralty trials, and in six runs reached a mean speed of 34·8 knots.

Her maximum speed was 35·6 knots. The weather was bad during the trials and there was a heavy swell on.

The *Viper* was lost during the Naval manœuvres in the summer of 1901, owing to her striking a rock in a thick fog.

The *Cobra* went down off the Outer Dowsing Shoal while on her way from the Tyne to Portsmouth, on September 1st, 1901.

H.M.S. "VELOX."

We have already mentioned that this turbine-engined destroyer differs from her predecessors, and the reason is because it was found that the *Viper* and the *Cobra* were not so economical as could be wished when running at ordinary cruising speeds. Excursion steamers and liners usually run at their highest speeds, but war vessels require full power only occasionally, and it was found that the steam turbine, like all steam engines, did not show high efficiency when working much below the power for which it was designed.

The arrangement of the machinery in the *Velox* is as follows: She has two sets of engines, one of the turbine type and the other of the reciprocating type. The main propelling machinery is much the same as that fitted in the *Viper* and *Cobra*. There are two independent sets of Parsons compound turbines, one high-pressure and one low-pressure being on each side of the engine-room. There are thus four turbines, each of which has its own line of shafting; as each shaft carries two propellers, there are eight propellers in all. The high-pressure turbines drive the outer shaft and the low-pressure turbines the inner ones. The turbines are the main engines for high-speed steaming, but for ordinary cruising an auxiliary propelling system is employed. This consists of two small sets of triple-compound marine engines of the ordinary type, which are coupled directly to the main turbines, and work in conjunction with them. They can, however, be disconnected at will. Steam is taken directly from the boilers to the reciprocating engines, and these exhaust through the high-pressure turbines, the exhaust from the latter passing in turn through the low-pressure turbines and thence to the condensers.

When higher powers than those needed for cruising speeds under ordinary conditions are needed, steam will be admitted to the turbines directly from the boilers. When, however, the highest speed is required, and the maximum power has to be developed which would raise the rate of revolutions beyond that permissible with reciprocating engines, steam will be entirely cut off from the latter, they will be thrown out of gear, and the turbine engines will alone be used.

For going astern, reversing turbines are incorporated in the exhaust casing of each of the low-pressure cylinders.

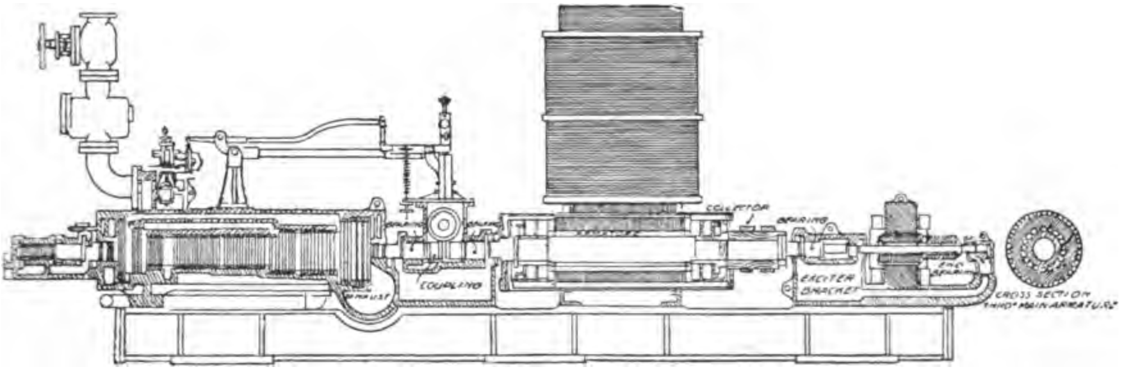
The *Velox* is 210 ft. long, 21 ft. beam, with a moulded depth of 12 ft. 6 in. Especial attention has been paid by her builders, Messrs. Hawthorn, Leslie and Co., to the strength of the hull, and they claim that she is the strongest destroyer yet built. The boilers are of the modified Yarrow type, and are the same as those fitted in the 30-knot destroyers. They are some 13 per cent. smaller than the boilers of the *Viper*, and have a total heating surface of 13,000 square feet. The builders anticipated that the *Velox* would have about the same speed as the *Viper*. Up to the time of writing, however, her maximum speed has been 33·64 knots, whereas the *Viper* made over 37 knots.

THE FUTURE OF TURBINE WARSHIPS.

Until the *Velox*, the *Eden*, and the *Amethyst* have run their trials, it is impossible to pronounce any definite and final opinion regarding the future of marine steam turbines as applied to men-of-war. Economy is not of the greatest importance here, but rather speed, and it would seem possible that (as Mr. Parsons has said) the benefit will be greater in the case of cruisers and battleships than in the case of smaller vessels. The larger turbines would be cheaper to build, would be lighter in weight, and would occupy less space in proportion to power. The design of large turbines appears to present no difficulties beyond those that have been successfully solved in the case of smaller craft, and the greater size will undoubtedly facilitate the introduction of important refixments for reducing coal consumption.

It may be interesting to quote here Mr. Parsons' description of an imaginary 44-knot cruiser which it is possible may some day actually be constructed :—

> It is, perhaps, interesting to learn the possibilities of speed that might be attained in a special unarmoured cruiser, a magnified torpedo-boat destroyer of light build with scanty accommodation for her large crew, but equipped with an armament of light guns and torpedoes. Let us assume that her dimensions are about double those of the 30-knot destroyers, or of the *Viper*, with plates of double the thickness and specially strengthened to correspond with the increased size and speed, length 420 ft., beam 42 ft., maximum draught 14 ft., displacement 2,800 tons, indicated h.p. 80,000. There would be two tiers of water-tube express boilers ; these, the engines and coal bunkers, would occupy the whole of the lower portion of the vessel ; the crew's quarters and armament would be on the upper decks. There would be eight propellers of 9 ft. diameter, revolving at about 400 revolutions per minute, and her speed would be 44 knots. She could carry coal at this speed for about eight hours, and she would be able to steam at from 10 to 14 knots with a small section of the boilers and supplemental machinery more economically than other vessels of similar size and of ordinary type and power, and when required all the boilers could be used and full power exerted in about half an hour.
>
> It may be remarked that in the history of engineering progress, the laws of natural selection generally operate in favour of those methods which are characterised by



SECTIONAL ELEVATION OF 150-KILOWATT TURBO-GENERATOR.

the greater simplicity and greater economy, whether these advantages be great or small.

THE STEAM TURBINE APPLIED TO PASSENGER VESSELS.

Two turbine-engined excursion steamers, the *King Edward* and the *Queen Alexander*, have been regularly running on the Clyde this summer. The Earl of Glasgow, in a recent presidential address to the Institution of Naval Architects in Glasgow, predicted that the *King Edward* would create a revolution in the coast passenger carrying trade in the Clyde. The following particulars of this vessel, the first turbine-engined passenger steamer in the world, may be of interest:—

Photo by W. Parry.]

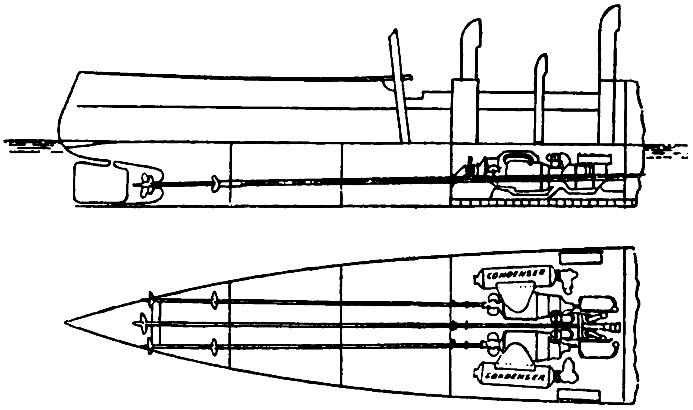
H.M. "VELOX" MAKING 33·64 KNOTS IN THE NORTH SEA, SEPTEMBER, 1902.

The *King Edward* is 250 ft. long and 30 ft. wide. Her moulded depth is 10 ft. 6 in. to the main deck, and 17 ft. 9 in. to the promenade deck. In general arrangement for passenger accommodation she is similar to the *Duchess of Hamilton*, a favourite Clyde paddle-wheel steamer. Her builders are Messrs. William Denny and Brothers, of Dumbarton, and she has been constructed to the order of Captain John Williamson, of Glasgow, who represents the syndicate which own her. The propelling machinery consists of three Parsons steam turbines working compound. These are placed side by side. In ordinary working, and when going ahead, steam is admitted from the boilers to the high-pressure turbine, where it is expanded fivefold. From thence it passes to the two low-pressure or wing turbines placed one on each side, where it is expanded 25-fold, and then passes to the condensers. The total ratio of expansion is therefore no less than 125-fold. Each turbine has its own shafting; and on each side of the wing shafts there are two propellers, while the centre one carries only a single screw. When coming alongside a pier, or manœuvring in crowded waters, the wing motors alone are used, steam being admitted directly into them by suitable valves. The high-pressure turbine is then shut off, the steam admission valve being closed, whilst connection between it and the low-pressure turbines is also shut off by an automatic arrangement. There are special turbines placed inside the exhaust ends of the low-pressure turbines for going astern with the wing screws. The whole of the manœuvring, excepting, of course, by the rudder, is effected by the manipulation of valves in a very simple manner. The feed-pumping engines are worked separately, as are the circulating pumps and fans for forced draught. The main air pumps are worked by means of worm-gearing from the wing shafts; but there are auxiliary air pumps, actuated by the circulating pump engines, for clearing the condensers of water when the main engines are not in operation. There is a feed-heater which uses the exhaust steam, or steam taken from an intermediate point in the turbines if necessary. There is also a filter to clear the steam of grease. Other machinery common to vessels of this class is fitted. The boiler is of the usual return-tube type, being double-ended, and having four furnaces at each end. It is placed in a closed stokehold.

On her first trial the *King Edward* made 20·48 knots, thus creating a record on the Clyde, and exceeding in speed most of the competitors by one or two knots. The mean revolutions were 740 per minute, the steam pressure in the boilers was 150 lbs. to the square inch, and the vacuum 28½ in.

The air-pressure in the stokehold was equal to 1 in. of water. The indicated horse-power was estimated at 3,500, but there is no available method of taking indicator diagrams with this type of motor.

The *Queen Alexandra* on her trials, in the summer of this year, made 21·63 knots, thus beating the *King Edward*, and, by a knot and a quarter, proving herself to be the fastest excursion steamer in the world.



ARRANGEMENT OF MACHINERY FOR PROPOSED 23-KNOT CRUISER OF 10,000 H.P.

She is very similar to the *King Edward*, but is of larger dimensions, her length being 270 ft., breadth moulded 32 ft., and depth to promenade deck 18 ft. 9 in. Like the *King Edward*, the vessel strongly resembles a small cross-channel steamer in appearance. The main engines consist of three separate turbines, each driving its own shaft, the centre turbine being high-pressure and the two side turbines low-pressure. The total ratio of steam expansion is about 125-fold as compared with 8 to 16-fold in triple expansion reciprocating engines, and at ordinary steaming rate the velocity of the centre shaft is 7,000, and that of the side shafts 1,000 revolutions per minute. A long shade deck, on which boats are carried and passengers are allowed to promenade, is a new feature in this vessel. The promenade deck itself extends almost the whole length of the vessel, and is fitted with buoyant seats.

The steam steering gear is by Messrs. Bow, M'Lachlan and Company, of Paisley, controlled by a wheel on the flying bridge. She is driven through the water by five propellers, and is reversed by astern turbines placed inside the exhaust ends of the low-pressure turbine cylinder, which reverse the action of the two shafts. A powerful windlass, with warping capstan attached, is fitted forward for working the main cables, and a steam warping capstan, both by Messrs. T. Reid and Son, of Paisley, is fitted aft for warping vessels alongside of piers. The vessel is lighted throughout by electricity, the installation being carried through by the builders; the wiring is done on the concentric system. The boiler, which is a large double-ended one, having a funnel at each end, is supplied by Messrs. Denny and Company; and the turbines, of which there are three, by the Parsons Marine Steam Turbine Company, of Wallsend-on-Tyne.

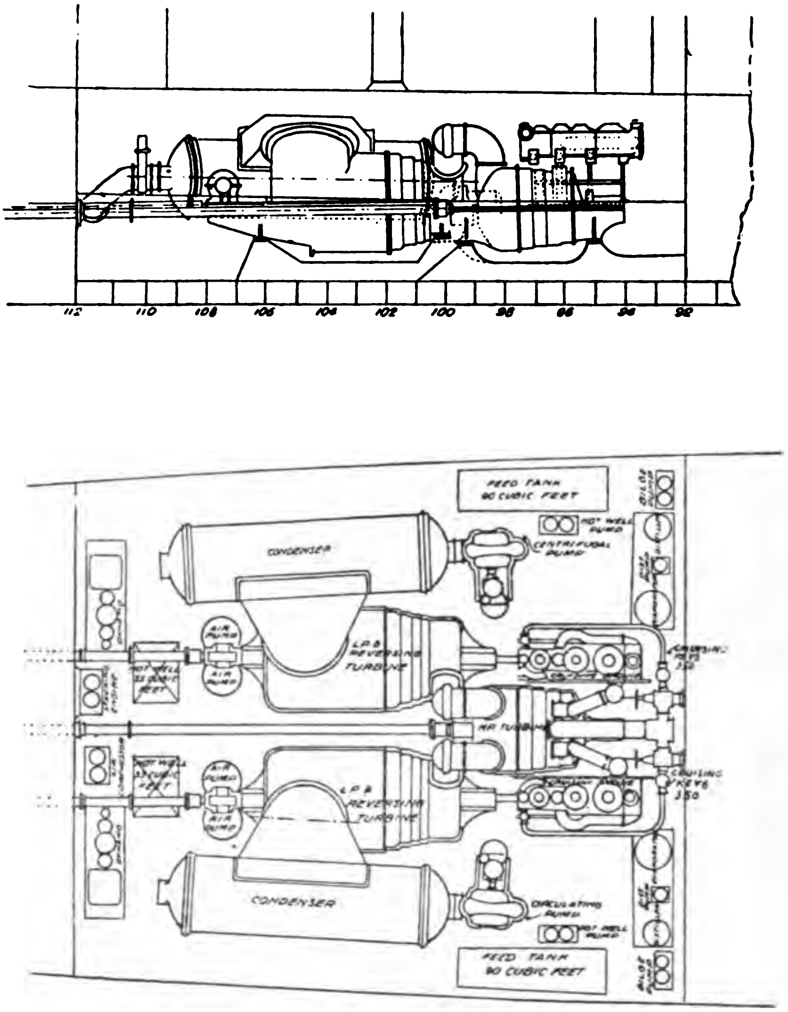
SPEED AND COAL CONSUMPTION OF TURBINE VESSELS.

At the launch of the *Queen Alexandra* Mr. James Denny made some interesting remarks respecting the speed and coal consumption of turbine vessels, which may be quoted here :—

Many irresponsible statements had appeared in the Press regarding the *King Edward*, so that perhaps it would not be out of place were he to give a few figures which were the result of actual experiments and trials with the vessel. If the *King Edward* had been fitted with balanced twin triple-expansion engines of the most improved type, and of such size as would consume all the steam the existing boiler could make, her displacement would have been slightly increased to carry the extra weight of triple engines as compared with turbines. Under these conditions, the best speed they could possibly have got would have been 19·7 knots, against 20·5 knots actually done by the *King Edward*. Thus the increase of speed was eight-tenths of a knot per hour. Two-tenths of this was due to the lesser displacement in the *King Eduard* as a turbine steamer, and six-tenths was due to the superior efficiency of the turbine engine and its accessories. The difference between 19·7 and 20·5 knots corresponds to a gain in i.h.p. in favour of the turbine steamer of 20 per cent.; but it would hardly have been possible to drive the *King Edward* 20·5 knots with ordinary engines at all, owing to the extra weight and the necessarily increased displacement. The attempt to do so could only have resulted in this speed being got at an enormously increased first cost and a ruinous expenditure of coal and the like on service.

Referring to the question of coal consumption, he said :—

The *Duchess of Hamilton* and *King Edward* results on service had been compared. From the comparison it had been found that the *Duchess of Hamilton* at 16·5 knots burned 16 tons, and the *King Edward* at 18·5 knots burned 18 tons. The *Duchess of Hamilton*, however, had only compound engines; by the use of triple engines her consumption could be reduced; but even with triple engines, if she were to be driven at 18·5 knots on service, her consumption would have been over 22 tons, as against 18 tons in the *King Edward*, which corresponded to a saving of about 20 per cent. in favour of the latter. This was on the assumption that the *Duchess of Hamilton* was left as she was in displacement and draught, and that she could have carried machinery powerful enough to



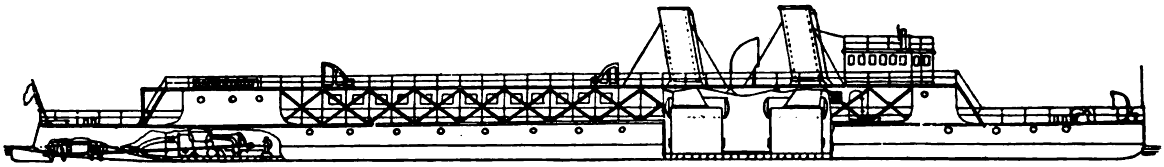
VIEW OF TURBINE MACHINERY FOR PROPOSED 23-KNOT CRUISER OF 10,000 H.P.

ensure 18·5 knots on service, but as her speed on trial was only 18 knots, the greater displacement necessary to carry the increased weight of machinery for the higher speed would have resulted in a considerable increase on the coal consumption of 22 tons. There was another question in regard to the coal consumption of turbines. It was well known that turbine engines at a much lower power than that for which they are designed are not so economical as ordinary engines. Up to the highest speed at which the *King Edward* had been driven they had found an always increasingly favourable consumption of coal in relation to the speed of the vessel, but they had no means of knowing how far this tendency might reach. However, they had ascertained that her speed would have had to be reduced to between 17 and 18 knots, as on trial, before ordinary engines, under the same conditions and at the same speed, would burn less per knot of speed; this 17 or 18 knots speed corresponded to about 50 per cent. of the total maximum power of the turbine engines in the *King Edward.* The up-keep of the turbine engines for the season had been very slight. As to cost, even including the royalties charged, they found that turbines were not more expensive than other engines, and they thought, with more experience in their manufacture, they would ultimately become considerably cheaper. If the *Queen Alexandra* turned out to be as successful as the *King Edward* was, it was almost certain there would be a very large application of turbine machinery.

ECONOMY OF TURBINES AT LOW POWERS.

The Hon. C. A. Parsons said he would like to supplement the statements of Mr. James Denny by a few remarks as to economy of turbines at low powers :—

In Clyde passenger steamers, indeed, in practically all passenger steamers, which always ran at or near full



DESIGN OF 26-KNOT SHALLOW-DRAUGHT BOAT, FITTED WITH TURBINE MACHINERY.

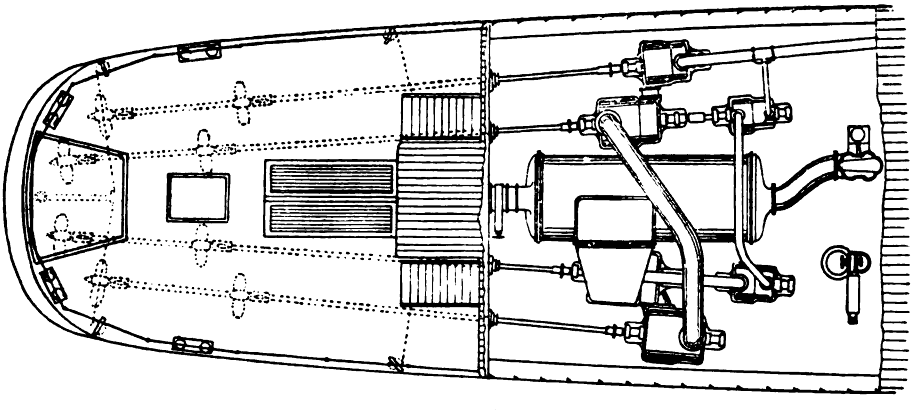
power, there was no need to study the question of economy at low powers, but when they came to war vessels, most of whose service was performed at cruising speed, when the power exerted was perhaps only one-tenth of that at full speed, then this question of economy at low powers became of great importance. Arrangements had been made to solve this difficult problem in several different ways. For instance, the number of turbines might be increased, and there was no doubt in his mind that they could by this and other means make turbines certainly as economical—probably much more economical than ordinary engines at the same low power—while at high speeds the turbines would have an advantage of from 20 to 40 per cent.

FORTHCOMING DEVELOPMENTS.

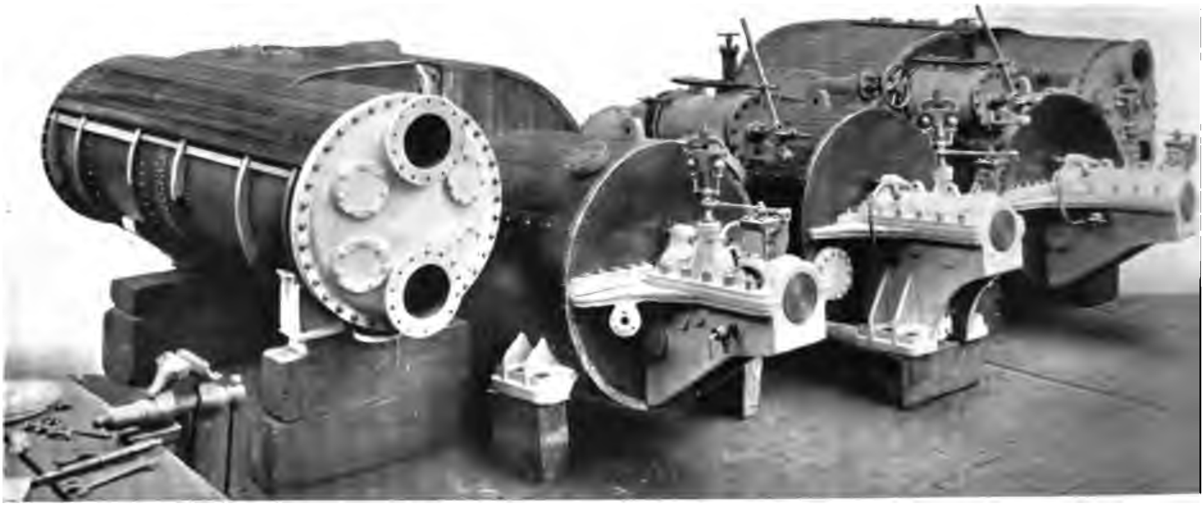
It has been announced within the last few weeks that the South-Eastern and Chatham Railway Co. have ordered a new turbine steamer, which is to be built by Messrs. Denny, and to be delivered for next season's traffic, and which for speed, comfort, and convenience is expected to create a revolution in cross-Channel passages. The length of the vessel will be 300 ft., and she will have a beam of 40 ft. She will be entirely different from the present type of mail packet. The upper or promenade deck is to have an over-head shelter, so that passengers can obtain protection in rough weather without going below. Extensive cabin accommodation will also be provided. The turbine machinery will occupy such a small space that much additional room will be obtained for the use of passengers. The builders calculate that the cross-channel passage between Dover and Calais will be covered by the new steamer in 45 minutes at the outside, and probably, under favourable circumstances, in less. The average passage now is 65 minutes, and the record passage is 59 minutes. The speed of the new steamer will be 25 knots an hour, as compared with the 18 to 20 knots made by the present boats on the present service. It has been stated that the Parsons Marine Steam Turbine Company have offered to fit up, free of cost, turbine engines on a Cunard liner, and that Mr. Wilson, President of the Atlantic Shipping Company, is negotiating for the construction of some 30-knot turbine steamships, which will make the voyage from New York to Bremerhaven in four days. Messrs. Denny are building also a turbine steamer for the London, Brighton, and South Coast Railway for their Newhaven-Dieppe service.

FUTURE OF THE MARINE STEAM TURBINE.

It may be interesting to quote here a statement made by the Hon. C. A. Parsons in a recent lecture at the Royal Institution, London, on the future of the marine steam turbine :—



VIEW OF TURBINE MACHINERY FOR 26-KNOT SHALLOW-DRAUGHT BOAT.



SET OF TURBINE MACHINES, AS FITTED IN THREE HIGH-SPEED YACHTS AND PASSENGER STEAMERS.

In regard to the general application of turbine machinery to large ships, the conditions appear to be more favourable in the case of the faster class of vessels, such as cross-Channel boats, fast passenger vessels, liners, cruisers and battleships; in all such vessels the reduction in weight of machinery and economy in the consumption of coal per horse-power are important factors; in some, the absence of vibration is a question of first importance as affecting the comfort of passengers, and, in the case of ships of war, permitting of greater accuracy in sighting the guns.

I have had constructed a model representing a proposed cross-Channel boat for the Dover and Calais or Newhaven and Dieppe routes. She is 270 ft. length, 33 ft. beam, 1,000 tons displacement, and 8 ft. 6 in. draught of water. She has spacious accommodation for 600 passengers, and with machinery developing 18,000 horse-power would have a sea speed of about 30 knots, as compared with the speed of 19 to 22 knots of the present vessels of similar size and accommodation.

Again, in a lecture delivered before the Institution of Engineers and Shipbuilders in Scotland, Mr. Parsons said that the marine steam turbine would be found to be superior, or at least equal in economy of coal to the reciprocating engine when placed in fast vessels of the mercantile marine. In the case of an Atlantic liner, turbine engines would effect a reduction in weight of machinery, and also increased economy in fuel, tending either to a saving in coal on the one hand, or, if preferred, to some increase in speed on the same coal consumption per voyage.

ITS PRINCIPAL ADVANTAGES.

The principal advantages of the turbine system of propulsion for passenger steamers of all classes, compared with vessels fitted with ordinary engines, are as follow:—

(1) Increased speed for the same boiler power due to considerably reduced weight of machinery and increased economy in steam. (The advantage increasing with higher powers and speeds.)

(1a) Same speed, with reduced boiler power and reduced coal consumption for the same reason as (1).

(2) Absence of vibration, giving greater comfort to passengers.

(3) Increased cabin accommodation, due to smaller machinery space.

(4) Less up-keep in machinery, and smaller engine-room staff.

HIGH-SPEED TURBINE YACHTS.

The possibilities of the steam turbine for yacht propulsion have recently been attracting the attention of the yachting world. Two yachts, which are to be fitted with the Parsons marine steam turbine, have recently been launched, whilst a third is in the stocks. Their names are *Tarantula*, *Emerald*, and *Lorena*.

The first to be launched was the *Tarantula*, built by Messrs. Yarrow and Co., of Poplar, for Col. McCalmont, M.P., from the design of

Messrs. Cox and King, of London. She is a unique vessel, in that she has been built on the lines customary with vessels of the torpedo-boat class. As regards her hull and boilers she is practically identical with a modern first-class torpedo-boat, the only difference being in the propelling machinery. Her boilers are of the Yarrow water-tube type, and we believe that she is the first yacht to be fitted with water-tube boilers. The *Tarantula* is 160 ft. long, with a 16 ft. beam; the machinery consists of three turbines, one high pressure and two low pressure. Each drives three shafts, and there are three propellers on each shaft. She is therefore driven through the water by nine screws. The question of propellers is one that has long exercised the attention of Mr. Parsons, and his experimenting may be expected to lead to important results. The trials of the *Tarantula* have been carried out with some secrecy. Her designed speed was 24 knots, and she is believed to have made 26·745 knots when loaded to a displacement of 150 tons. Doubtless a full series of trials will be made, and comparison will then be possible between the turbine-driven *Tarantula* and a first-class torpedo-boat whose engines are of the reciprocating triple-expansion type, and whose horse-power is about 2,000.

THE "EMERALD."

The *Emerald* was launched the other day. She was constructed to the order of Sir Christopher Furness, M.P., D.L., from the designs and under the direction of Mr. Fred. J. Stephen, the managing director of the Linthouse Shipyard, Glasgow, by Messrs. Alex. Stephen and Son, Ltd. She is 236 ft. long, 28 ft. 8 in. beam, and 18 ft. 6 in. moulded depth, giving a tonnage of 956 tons yacht measurement. She has been constructed under Lloyds' special survey to class 100 A1. Her propelling machinery consists of three sets of Parsons steam turbines, each of which drives one propeller shaft, one propeller of about 3 ft. diameter being attached to the centre, and two propellers, each of about 20 in. diameter, to each of the side shafts.

At the launch of the *Emerald*, Sir Christopher Furness remarked that what Mr. Parsons, Mr. Stephen, and he himself had in view in fitting the *Emerald* with turbines, was to put into the vessel such power as would enable her to steam at the highest rate compatible with entire freedom from vibration. He believed that object would be attained, and still further he believed, as a business man and as one engaged with ships and shipping, that the steam turbine would practically revolutionise yachting and yacht owning in this country.

Mr. G. L. Watson, the well-known yacht designer and yacht builder, on the same occasion, said that if the marine steam turbine was proved to be economical at low speeds it certainly had a great future.

The *Tarantula* has been designed as a yacht of exceptionally high speed (24 knots), but the *Emerald* is to steam 16 knots at her maximum. Seeing that yachts seldom cruise for long periods at so great a speed as 16 knots, but for the most part indulge in gentle cruises at lower speeds, it seems doubtful whether yacht owners will take very keenly to the steam turbine. Whether the *Emerald* will prove as economical as regards coal consumption at various speeds as a similar yacht with reciprocating engines remains to be seen.

As regards vibration, it is doubtless possible so to strengthen the hull as to prevent any discomfort from the rapid revolution of the propeller shafts.

THE "LORENA."

Another turbine yacht under construction at the present time is the *Lorena*. The hull and boilers are being supplied by Messrs. Ramage and Ferguson, of Leith, Scotland, and the machinery by the Parsons Company. She is being built to the order of Mr. A. L. Barber, of New York. She will displace about 1,400 tons, and she will be 252ft. 3in. long by 32ft. 6in. beam, and moulded depth 21ft. Her indicated horse-power is to be 2,500, and her speed about 16 knots. She has been designed by Messrs. Cox and King, of London. The turbine machinery will be very similar to that fitted in the *Emerald*.

MILLING MACHINES.

BY

JOSEPH HORNER.

Treats of Profiling Machines, in which outlines of irregular shape are produced by the aid of a pattern or former similar in outline.

VI.

In profiling machines, which are now very numerous, there is a large range of sizes; and besides this, numbers of ordinary vertical spindle machines have provision for converting them into profilers when required.

It is because irregular outlines are so very costly to shape by any other method in other machines, or by hand, and are practically incapable of interchangeable production by such methods, that the milling machine is of the highest value, and scores most heavily in this class of work.

GENERAL CONSTRUCTION.

The principle is illustrated in fig. 1, in which A is the former, B a pile of work, the shape of each piece in which is controlled by the movement of the tracer, C, around the edge of A. The spindle head or slide, D, is free to follow the irregular movements of C. The exact longitudinal adjustments of C are provided for in large machines by a sliding block, E, in which the stem of C has its bearings, and these are controlled by a screw. The taper form is imparted to the tracer pin, C, in order to provide for coarse and fine depths of cut, effected by raising or lowering the tracer.

It is easy to understand that in movements of this kind any lost motion in the fitting, either of the spindle and its head, or of the tables, would be fatal to accuracy of results. Provision is therefore made for taking up wear as soon as it begins to develop.

In all the lighter types of profilers there are two movements to the cutter, one horizontally by the sliding of the head bodily, and one vertically by the sliding of the cutter spindle alone. The first is controlled by the former and tracer pin, the second by hand. In most machines the head and pin are maintained in contact with the former by the pull of a suspended weight. In some of the smallest machines, however, a handle alone is used for imparting the pull. The sliding head in good machines is carried on rollers on the top edge of the horizontal, or cross rail, to lessen friction. In order to allow for the ever-changing horizontal positions of the sliding head, the spindle pulley is driven by a half-crossed belt from a long drum at the rear. The work is carried on a sliding table, which is operated by hand or by power.

A TYPICAL MACHINE.

The mechanism of a profile milling machine is best studied in the front and side elevations, given in figs. 2 and 3, of one of the latest forms built by Messrs. Webster and Bennett, of the Atlas Works, Coventry.

The spindle, A, is driven from the long drum, B, on the same shaft as the three-stepped cones,

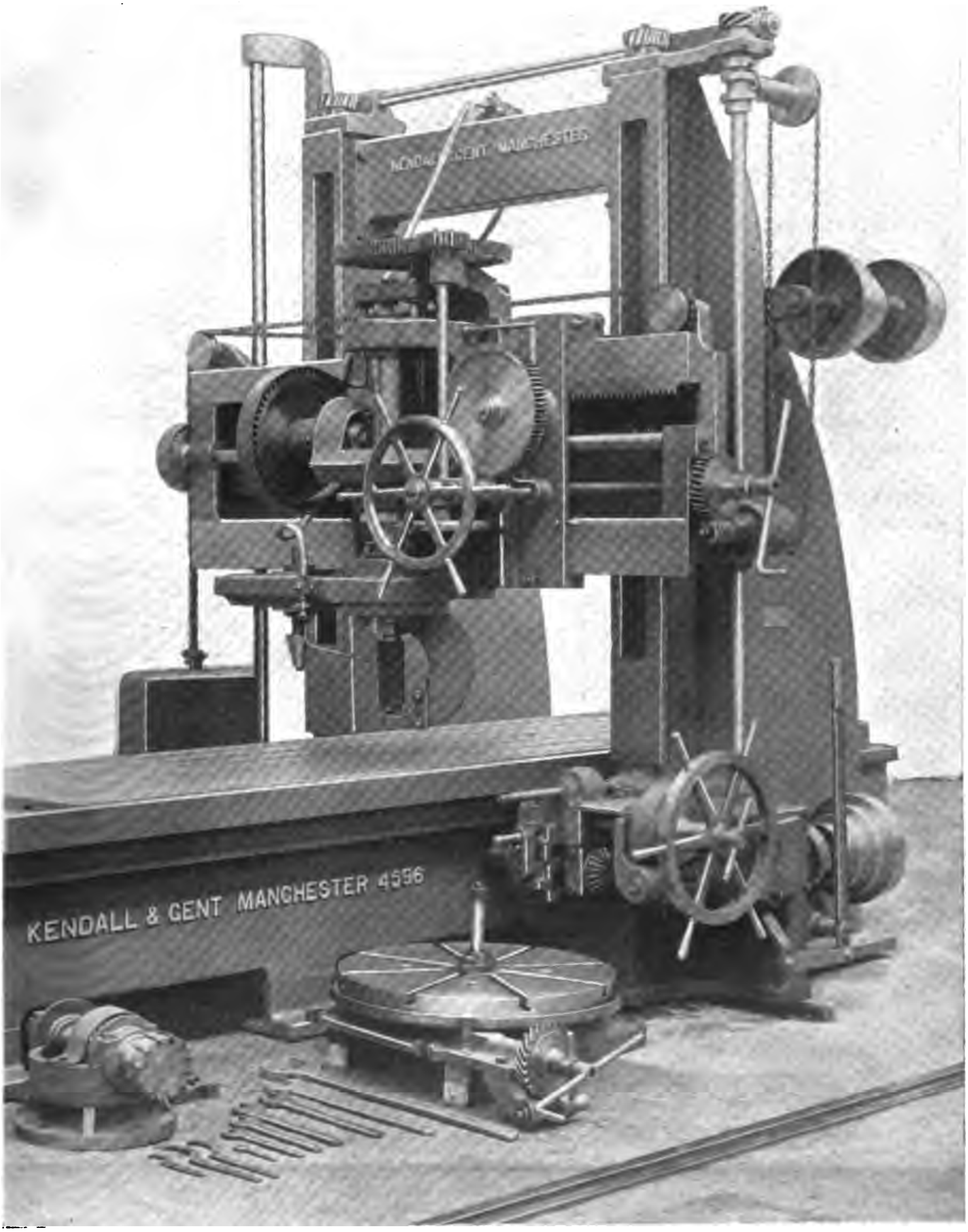


FIG. 16. HEAVY PROFILING MACHINE.
KENDALL AND GENT, MANCHESTER.

with a quarter-twist belt. The slide, C, in which the spindle has its bearings, has a range of vertical travel on the carriage, D ($3\frac{1}{2}$ in. in this case), and is counterbalanced by the weight, E, at the end of the quadrant rack. The carriage, D, runs on its cross rail, on rollers, in order to render its working as easy as possible ; *a* is the former pin, which being held against the former or pattern by the weight, F, and so pulling the slide, D, imparts its pattern to the work upon the table. By clamping the saddle on the cross slide the machine can be used as a vertical miller for plain work within its range, including such operations as slot drilling, face milling, etc.

The table feeds include one longitudinal, accomplished in this case with rack and pinion, and a circular drive with worm gear. The longitudinal feed is derived from the stepped cone, F, through spurs, bevels, worm and worm wheel, and again through spurs to the rack, the course of which is clearly indicated in the two views. Stops, *bb*, strike a lever, *c*, and reverse the motion through the claw clutches on the worm shaft. The table can be moved and adjusted by hand from G. The gear for the feed of the circular table is seen at the right of fig. 2. It comprises worm and spur gears, which can be thrown out instantly by the clutch, by hand. The table has the sud trough round it, without which no machine is now considered complete. All the gears are machine cut, and protected by guards. Provision is made for taking up wear, so that no lost motion shall occur in the movements of the table. A pump is seen at H, belted from the main driving shaft. The body of the machine forms a tank for suds. A tool cupboard is also fitted. The spindle is of steel, hardened and ground, and runs in adjustable bearings of gun-metal.

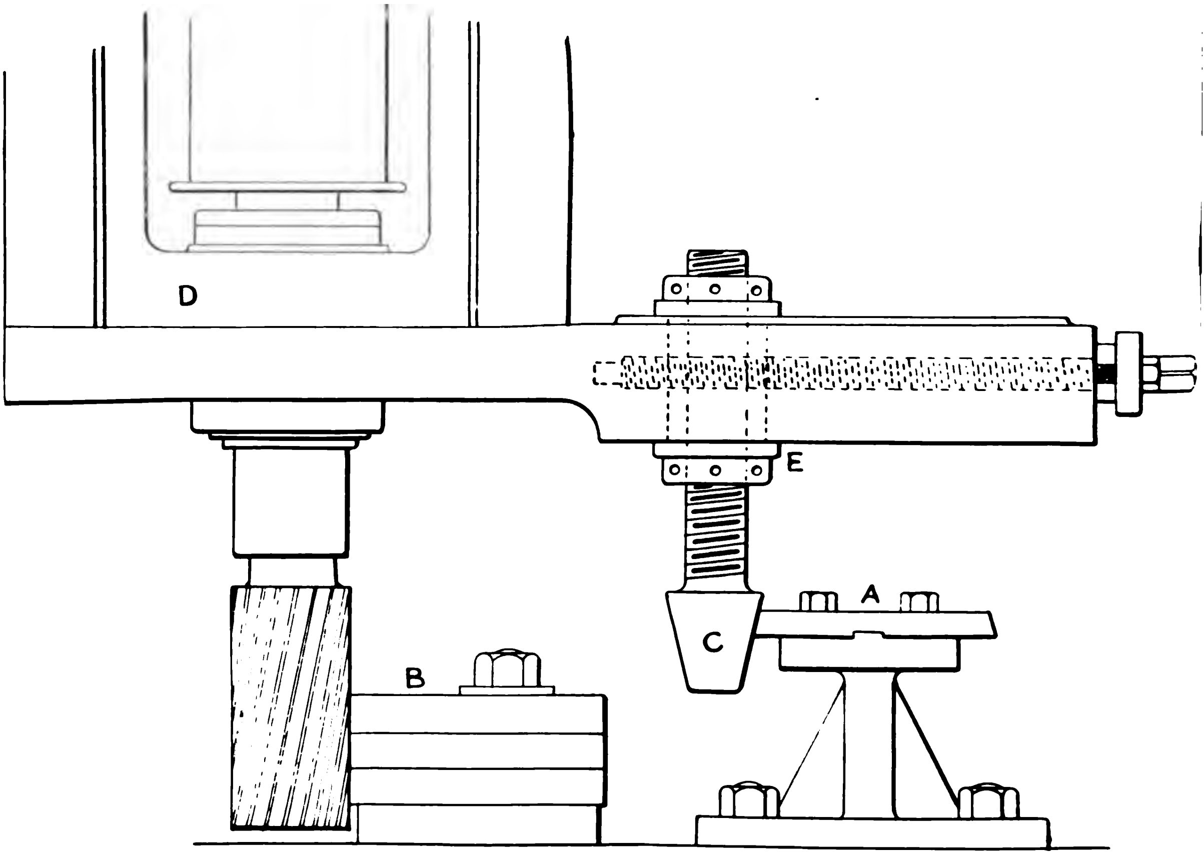


FIG I.

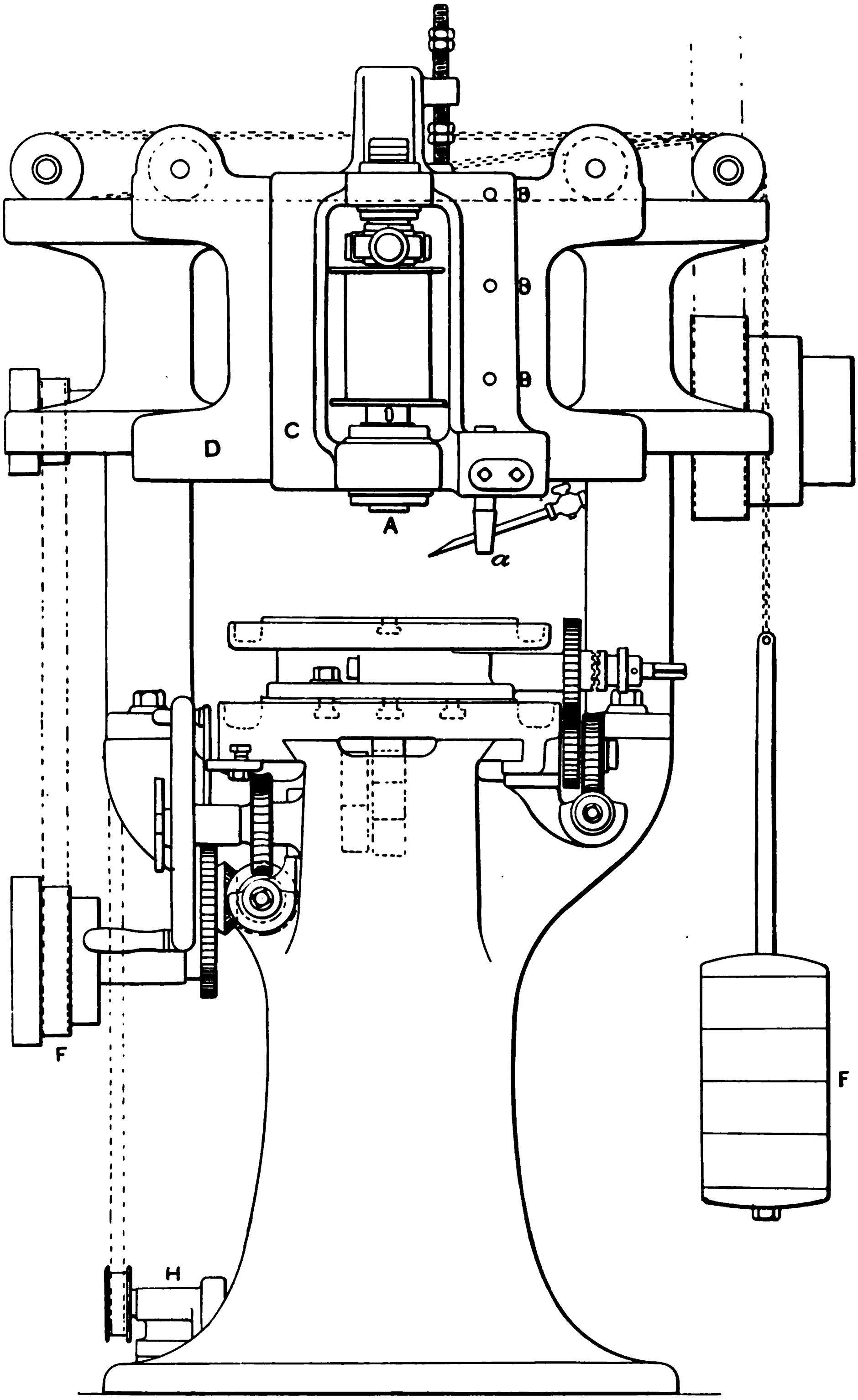


FIG. 2.

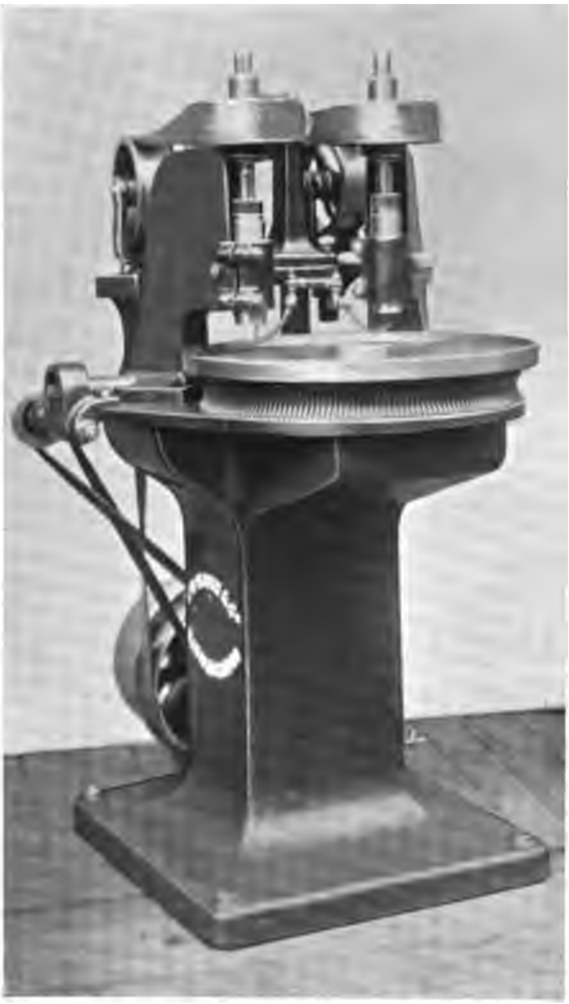


FIG. 4. DOUBLE-SPINDLE VERTICAL MILLING MACHINE. H. W. WARD AND CO., BIRMINGHAM.

The end thrust is taken on ball collars. This machine weighs about a ton.

TWO-SPINDLE MACHINES.

A good many machines are made with two spindles, examples being given in figs. 8 and 17. These machines fulfil two useful functions, since each spindle can be used on a separate piece of work dissimilar, or else identical, in form. In the first case the output is doubled; in the second, one spindle will take a roughing and the other a finishing cut.

THE WARD MACHINE, WITH TWO SPINDLES.

Figure 4 illustrates a very handy two-spindle machine by Messrs. H. W. Ward and Co., of Birmingham, which, though not a true profiler, may be considered as a connecting link between the plain vertical spindle machines, and the profilers. It is designed for doing circular work, the edges of which can be milled to any sectional form. The table is rotated by worm and wheel, and the spindles are driven by a single belt passing around idlers to flanged pulleys at the spindle heads. The advantage of being able to take a roughing and a finishing cut on work without resetting is very great. The value of this when large numbers of similar pieces have to be turned out to interchange is obvious. A pump supplies lubrication, which is drained off into the body of the machine, to be pumped up again.

THE ARCHDALE MACHINES.

Messrs. James Archdale and Co., of Birmingham, make a speciality of profiling machines, of which the firm manufactures several sizes and types, forming an important section of the plant for arsenals. Fig. 5 illustrates one of the smaller sizes, having an 8-in. horizontal traverse of the spindle, and a table measuring 15 in. by 12 in. The horizontal drum from which the spindle is driven is partly seen behind, and also the counter-balance of the spindle. The horizontal slide runs on rollers, and the same lever at the front, which moves the vertical slide, also pulls the horizontal slide and pin against the former or pattern. The table feed is by a hand wheel, through spur gears to a rack, and the wheel which gears with the rack is in halves, so that back lash can be taken up. The machine framing contains a reservoir for suds, which are pumped thence up to the cutter.

A heavier machine by this firm is shown in fig. 6, in which, instead of being merely hand-operated, all motions are self-acting. The cross slide is pulled over to its work by a weight, and it has self-acting transverse traverse by worm gears and a screw. The vertical slide is counterbalanced by springs, and adjusted by hand wheel and screw. The table is fed and reversed automatically in the longitudinal direction, and the removable circular table is also self-acting. The base is utilised as a tank.

A very fine profiling machine by the same makers is shown in fig. 7, being back-geared, and having a table measuring 4 ft. 6 in. by

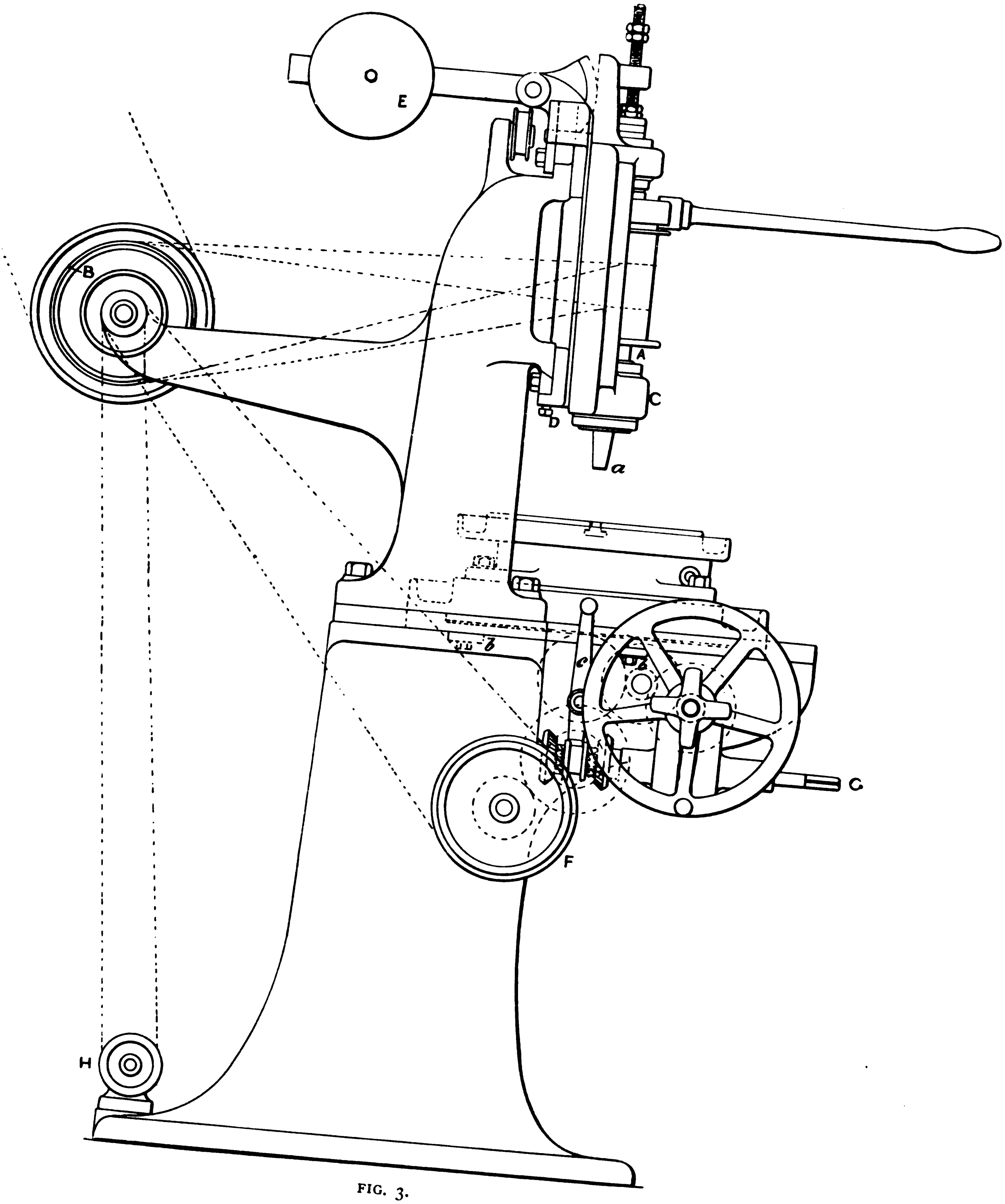


FIG. 3.

2 ft. 4 in. The machine can be used as a profiler, or for ordinary work. For the former it is furnished with a chain and weights, for the latter the cross slide is rendered self-acting by gears. The vertical slide is counterbalanced by a weight dependent from chains. The table has quick return motion in each direction. All feeds are self-acting, and all have hand adjustments also. The feeds are driven through friction. There are sixteen changes of speed to the cutter spindle.

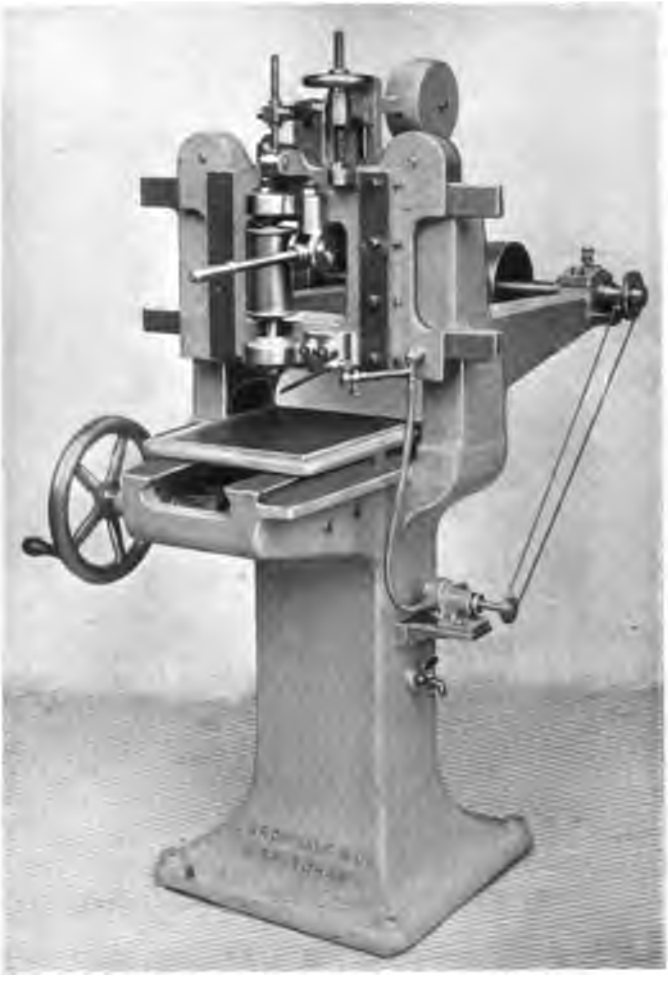


FIG. 5. ONE OF THE SMALLER PROFILING MACHINES.
J. ARCHDALE AND CO., BIRMINGHAM.

A DOUBLE-SPINDLE REINECKER MACHINE.

A large profiling machine (fig. 8), by J. E. Reinecker, of Chemnitz-Gablenz, represented by Messrs. Pfeil and Co., of Clerkenwell, differs in several respects from other designs. Thus, it has separate spindles for slow and quick speeds, the latter being driven from the former. But the wear on the large slow-speed spindle is much less than it would be if run at a high rate of revolution. When the main spindle is in use, the secondary one is thrown out of gear. In the machine shown the spindle rates are as three to one. The driving is done through stepped cones and back gears, having a ratio of 16½ to 1, and bevel wheels to the spindle. Another feature is that instead of the profiling action being effected by drawing over the spindle head against a former, the table slide is

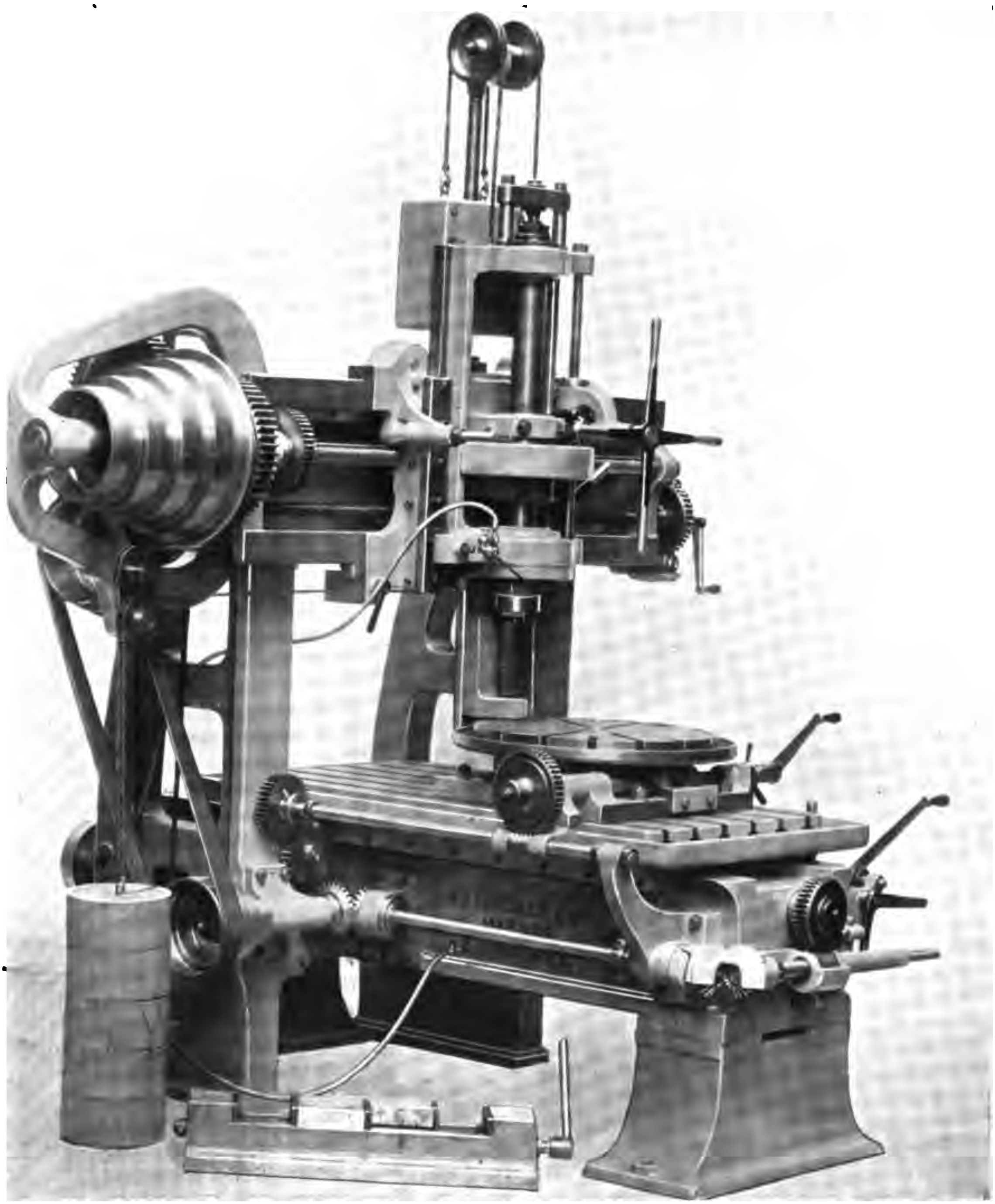


FIG. 7. VERTICAL MILLING MACHINE, WITH PROFILING ACTION.
J. ARCHDALE AND CO., BIRMINGHAM.

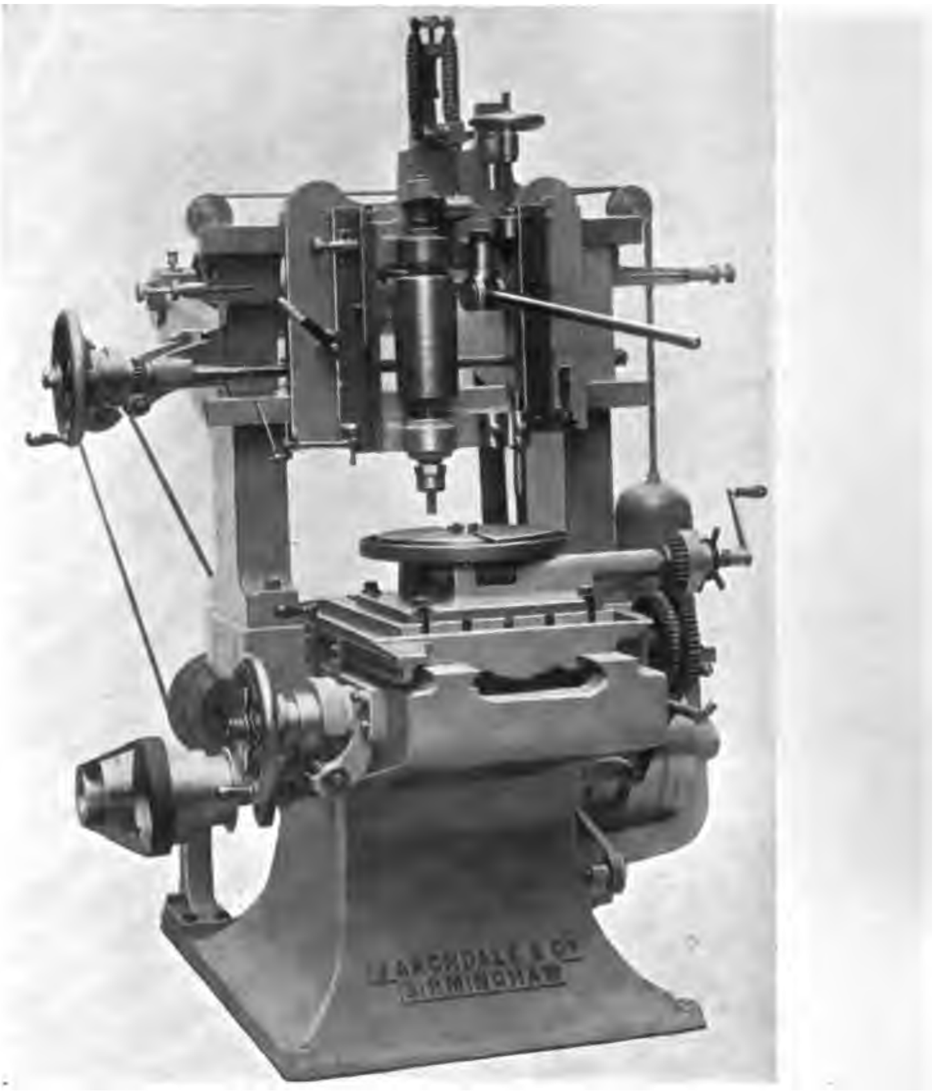


FIG. 6. SELF-ACTING PROFILING MACHINE.
J. ARCHDALE AND CO., BIRMINGHAM.

moved. The profiling roller is carried in a bracket which is bolted to, and adjustable on the base of the main frame. Circular milling is provided for by a round table, not shown. Feeds are automatic, the transverse feed varies from $\frac{5}{16}$ in. to 7 in. per minute. The table has a quick return motion, nineteen times faster than the feed. The size of the machine is a striking feature. It weighs nearly $8\frac{1}{2}$ tons, and the working surface of the table measures 6 ft. $2\frac{5}{8}$ in. by 1 ft. $11\frac{3}{8}$ in. The bottom spindle bearing is $6\frac{5}{16}$ in. in diameter, by $11\frac{7}{8}$ in. long, the upper one $4\frac{3}{4}$ in. by $8\frac{5}{8}$ in.

SPECIALISED MACHINES BY WEBSTER AND BENNETT.

Messrs. Webster and Bennett, of Coventry, make some patented profile milling machines of unusual and interesting types, both horizontal and vertical. Two horizontal machines are shown in figs. 9 and 10, the first for work of a general character, the second for special purposes.

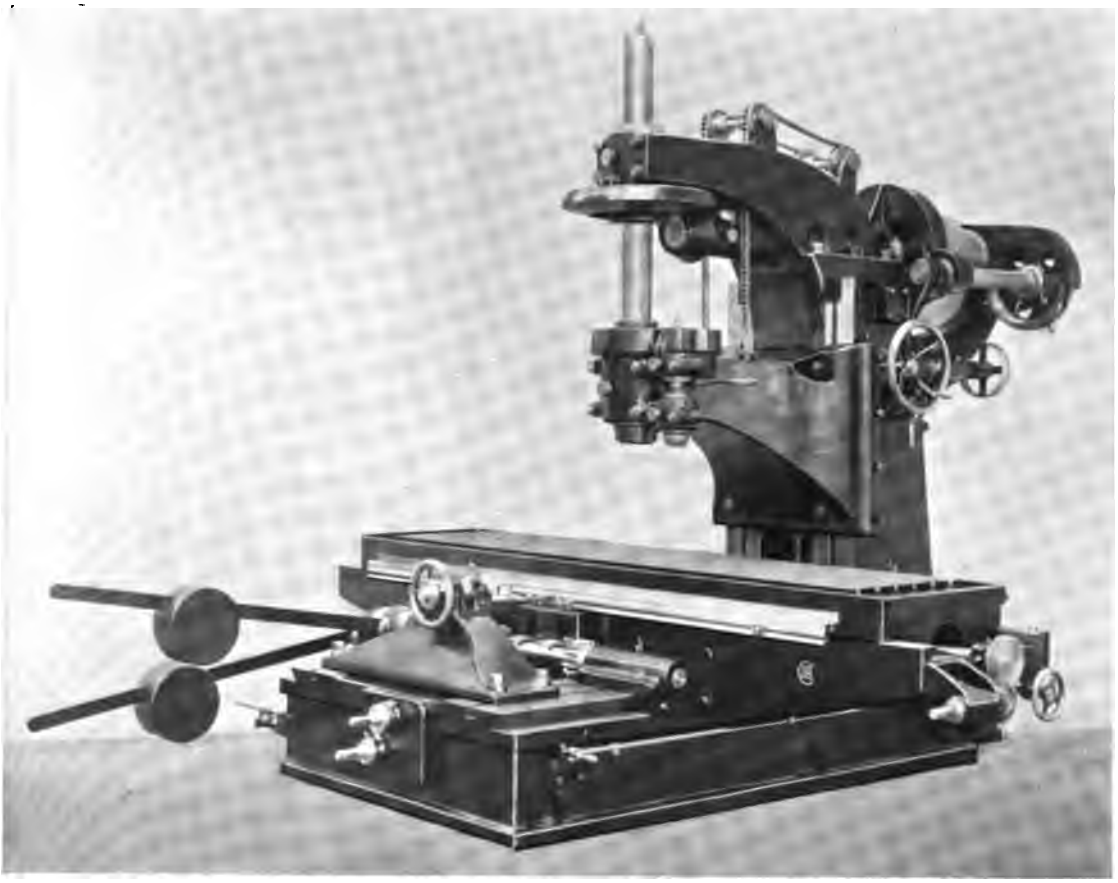


FIG. 8. HEAVY PROFILING MACHINE.
J. E. REINECKER, CHEMNITZ-GABLENZ.

The machine in fig. 9 is double-headed—that is, there are two cutter heads, and two work heads carried on one bed, so that one attendant can mind two pieces of work. The weights seen below hold up the roller or tracer against the cam or former plate, and so move each work head to and fro. The hand levers seen in front are used to pull the heads to the front when work has to be changed. The four-stepped cones drive worm gear, by which the work is rotated, but the worm is provided with a friction clutch and releasing attachment, by means of which awkward shapes can be milled. (See figs. 12 to 15.) This machine is suitable for milling cams, links, small levers, glands, squares, hexagons, etc., used on steam and water fittings.

The machine shown in fig. 10 has been specially designed for milling the cams of motors and similar work, when the cams are solid with the shaft, or loose.

The piece is held in a three-jaw self-centring chuck, which grips the shaft on its journals or turned parts. The portion operated upon is close to the chuck, and the job is still further supported by a steady. The former plate is immediately behind the chuck, and the whole is revolved against the cutter by worm gearing. The bracket at the extreme right supports the end of the shaft, and is provided with a division plate to ensure the different cams along the shaft being in the correct relation to each other. After each cam is milled, the chuck is opened, and the shaft slid through the hollow spindle far enough to bring the next cam into position. The bracket at the extreme right slides with the cam shaft, the dividing plunger being withdrawn before the feed motion is started. The cutter is carried in a head which slides to and from the bed at the back. The tracer roller is mounted upon it, and is kept up to its work by a weight and chain. A hand lever at the front withdraws the cutter from the work while a change is being made. For milling loose cams a short mandrel is fixed to the former plate in place of the chuck. The bed of the machine rests on a sud tray, and a pump is provided.

The vertical profile milling machine in fig. 11 is another speciality of Messrs. Webster and Bennett. In its essential mechanism it resembles the horizontal machine, fig. 9, but the work head is made to slide on a vertical bracket instead of on a horizontal bed. Its value lies in the tooling of pieces that lie outside the range of the horizontal machine. The work is fastened to a cam plate carried on the end of a large hollow spindle, through which a bolt runs for securing the mandrel in the spindle end. The various movements—circular, vertical, and trip—are controlled by adjustable dogs. The slide which carries the spindle is counterbalanced.

The sketches (figs. 12 to 15) will serve to illustrate the many and varied pieces which are dealt with on these machines, and the method of their operation. Figs. 12 and 13 show a cycle-fork crown attached to the cam plate, and just commencing its revolution in the direction of the arrow, the cutter, of course, running against it. The cam plate is held against the roller by the weight in the ordinary manner until the position at fig. 14 is reached. At this point the cam is assisted by a roller at the rear

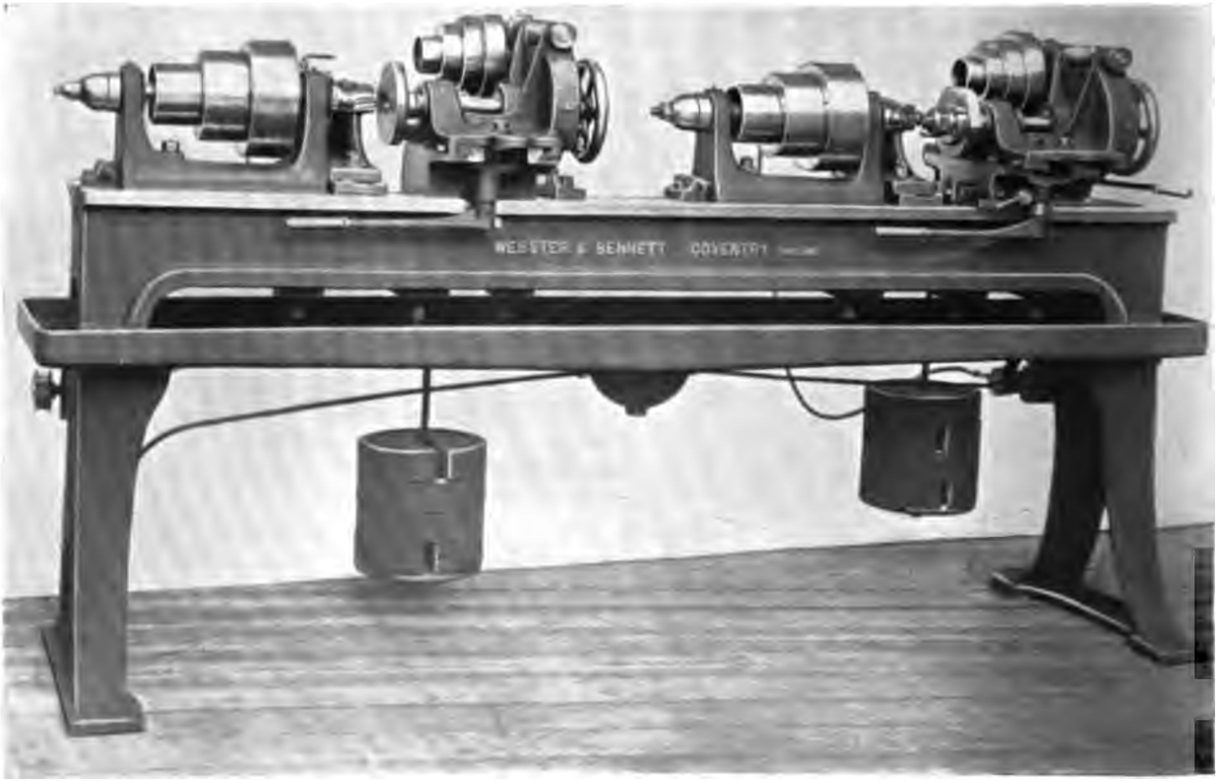


FIG. 9. DOUBLE-HEADED HORIZONTAL PROFILE MILLING MACHINE.
WEBSTER AND BENNETT, COVENTRY.

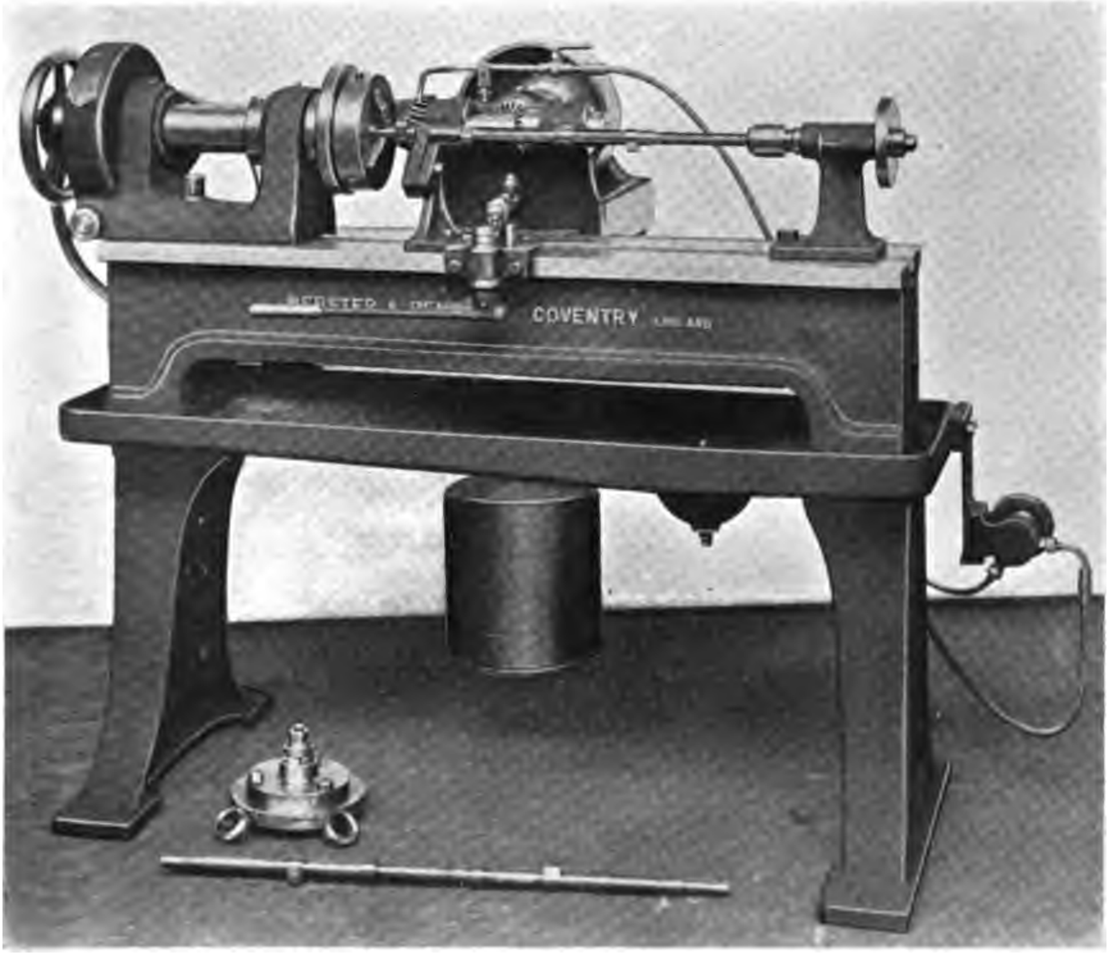


FIG. 10. MOTOR CAM SHAFT PROFILE MILLING MACHINE.
WEBSTER AND BENNETT, COVENTRY.

of the automatic head. Its action is shown in fig. 15. An inclined bracket is bolted to the bed, against which the roller pushes, with the result that, as the bracket cannot move, the whole head is pushed over bodily in the direction of the arrow. This, of course, draws the cam out of its awkward position—shown in fig. 14—and allows it to proceed on its revolution. This action occurs twice in each revolution, the large worm wheel being mounted on a friction cone, to enable it to slip slightly in the operation, the lost motion being taken up in a division plate, the small holes of which are indicated in fig. 15.

MODIFICATIONS IN DESIGN.

Many profiling machines have heads without any range of vertical movement, the only movement available in this direction being that imparted to the spindle itself by the hand lever. In the smaller machines of the pillar and knee type, the knee supplies the means for increasing the vertical range. In the heavier machines of the planer type the cross rail can be raised and lowered on the housings. So that in the heavier and the lighter machines we have two entirely distinct arrangements for increasing the capacity of these machines to suit work of different heights. In an intermediate class, in which the machine is usually carried on a cupboard base, and which supports the table slides, the cross rail, though frequently rigidly fixed with the housings, is also sometimes made movable thereon, as in the planer type.

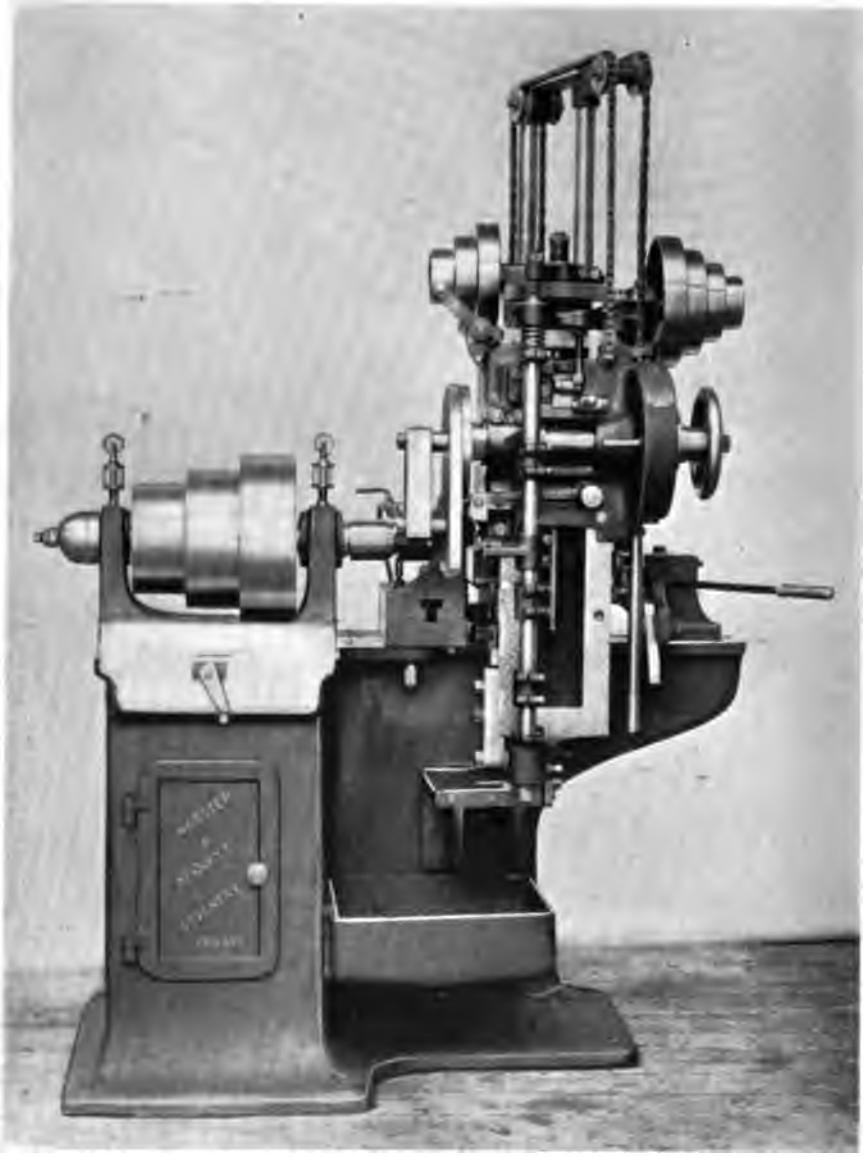


FIG. 11. VERTICAL PROFILE MILLING MACHINE.
WEBSTER AND BENNETT, COVENTRY.

Figure 16 illustrates a large profiling machine of the planer type, by Messrs. Kendall and Gent, of Manchester, which, of course, is equally suitable for plain and circular milling. The feature to be noted in this machine is that the spindle is not driven by a belt from a drum at the rear, but through toothed gearing, a practice which is adopted in a good many of the heavier machines.

THE WESSON DRIVE.

The belt difficulty in profiling machines, where the position of the head is constantly changing, is obviated by the recently patented Wesson drive. It is applied to the machines of the Garvin Machine Company, represented in England by Messrs. C. W. Burton, Griffiths and Co., of Ludgate Square, E.C. The essential feature is that the profiling spindle, or

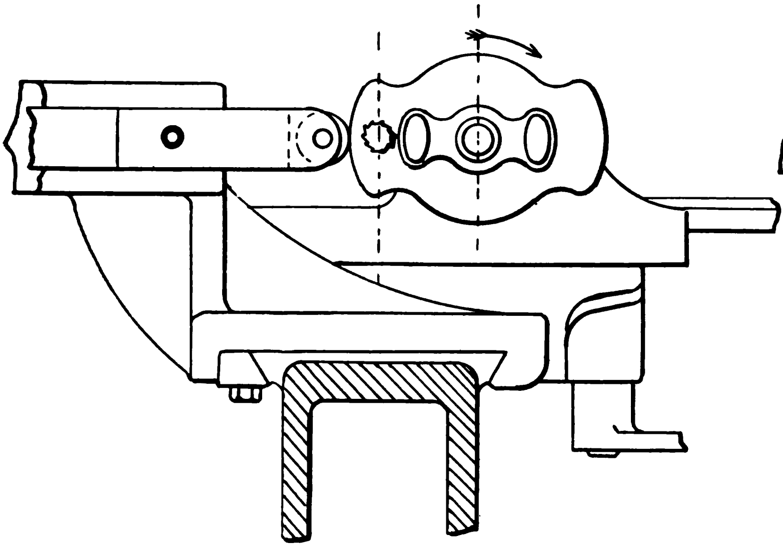


FIG 12.

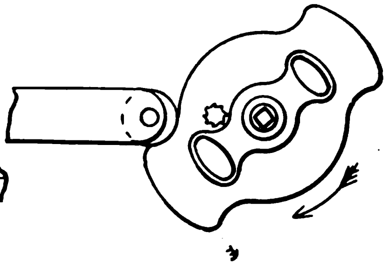


FIG 14.

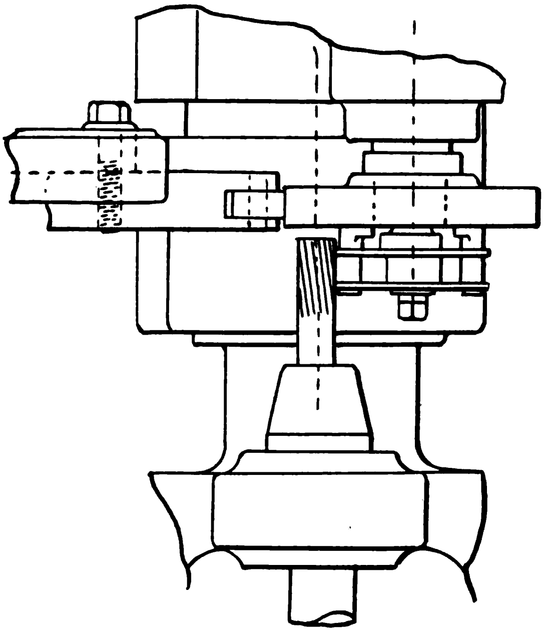


FIG 13.

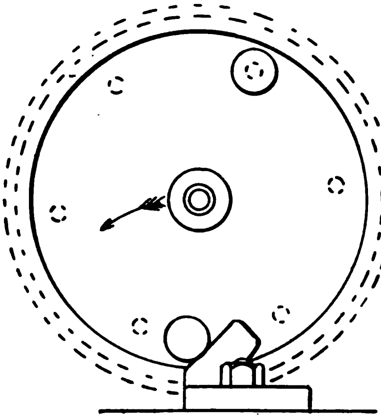


FIG 15.

spindles, are driven directly from the counter-shaft by telescopic shafts. One of the two-spindle profilers made by this firm, fitted with the drive, is shown in fig. 17. The telescopic rods which come down to the top ends of the spindles are made to suit the height of the ceiling of the shop. The countershaft is of a special type. A single casting carries the whole of the pulleys. A three-speed cone pulley, with an internal friction clutch, is belted from the main line shaft. Two pulleys on the cone shaft drive two small flanged pulleys on vertical shafts, which are jointed to the telescopic spindles. The direction of rotation of one or of both spindles can be changed by sliding the hinder pulleys sideways, and reversing the belt. The weight of the telescopic spindles is taken on roller thrust washers. The joints are fastened to the spindles and shafts with keys, secured by taper pins rivetted over at both ends. The joint pins are tapered, and secured by lock nuts. In the centre of the pin block there is a hole which contains felt, kept saturated with oil, which is driven out to the pin by centrifugal force, and so lubricates the joint.

THE GARVIN MACHINES.

Apart from this interesting drive, which obviates much of the vibration caused by belts, and does not block the light so much in the shop, the Garvin machines possess several good points.

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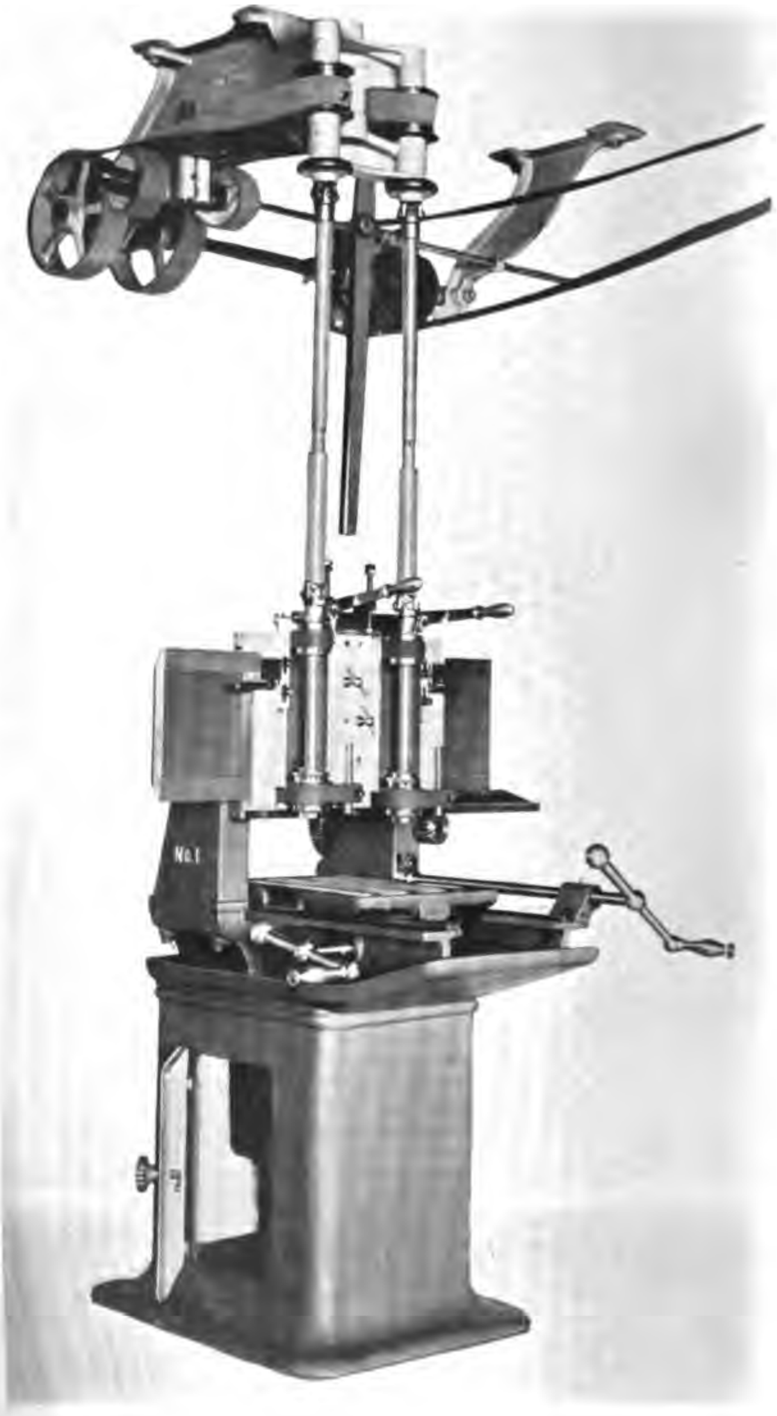


FIG. 17. GARVIN TWO-SPINDLE PROFILER, WITH WESSON DRIVE.

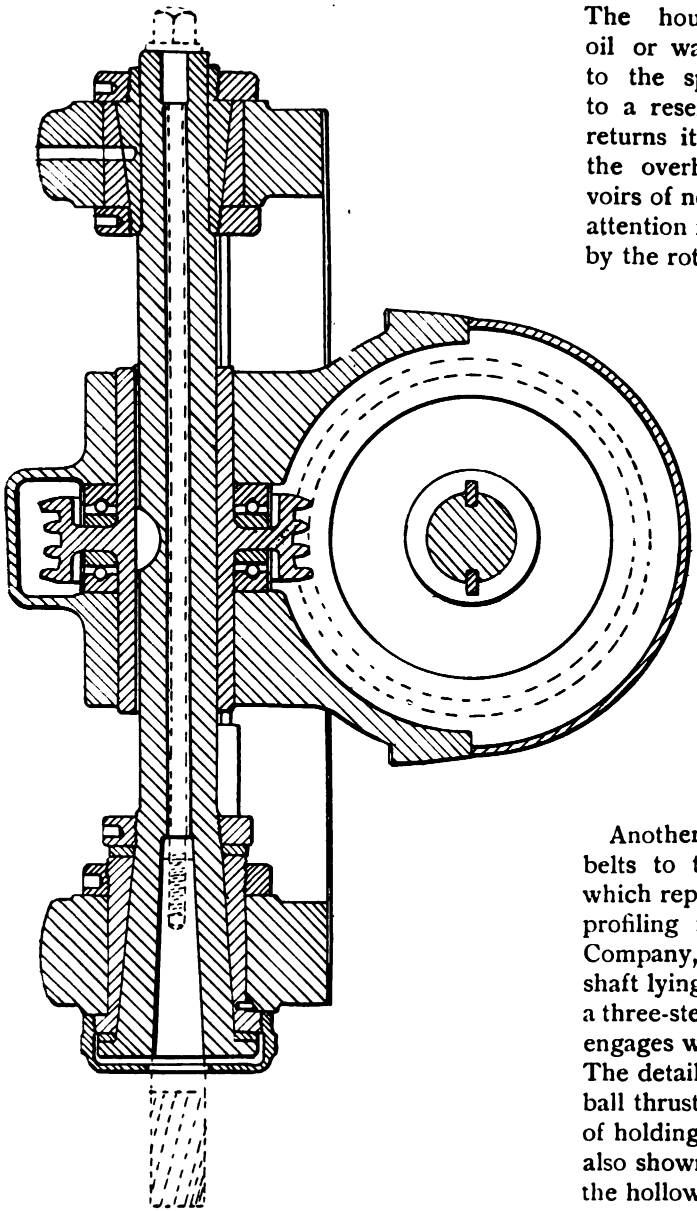


FIG. 18.

The housings are utilised as reservoirs for oil or water, and flexible pipes lead thence to the spindles. The lubricant is led back to a reservoir in the base, whence a pump returns it to the housings. The hangers in the overhead are supplied with large reservoirs of non-fluid oil, which lubricates without attention for a long time, and is not thrown off by the rotation of the shafts. A large oil groove round the table keeps grit off the slides. The spindle slides are balanced. They have adjustable lock tops, micrometer adjustments, and screw gauge stops. Stops are fitted to the table movement, and back lash is taken up on the pinion and rack that drives the table. The lever usually employed for controlling the movement of the cross slide is replaced by a crank handle and gearing, giving the operator greater command over his work, with less effort on his part.

THE NEW PRATT AND WHITNEY SPINDLE DRIVE.

Another recent drive, which does away with belts to the spindle, is illustrated in fig. 18, which represents the spindle of a double-spindle profiling machine by the Pratt and Whitney Company, of Hartford. A horizontal splined shaft lying along the cross rail, and driven from a three-stepped cone, carries a spiral gear, which engages with a similar gear on the cutter spindle. The details shown in the drawing, including the ball thrusts, are self explanatory. The method of holding in the taper shanks of the cutters is also shown dotted, a long bolt passing through the hollow spindle, in the manner common to light machines.

WORKSHOP PRACTICE

A RÉSUMÉ OF MACHINE TOOLS, CRANES, AND FOUNDRY MATTERS FOR THE MONTH.

MACHINE TOOLS.

WE illustrate one of the Milwaukee milling machines, for which Messrs. Schischkar and Co., Ltd., of Birmingham, are the English agents. A general idea of the design can be gathered from the photo (fig. 1), while the heavily shaded portions in figs. 2 and 3 show the vertical spindle, and the rack cutting attachments. The machine is interesting as representing high-class American practice by a firm who offer a welcome to all visitors, and who work only in specialities.

The headstock is curved upwards at the rear of the pulleys, in lathe head fashion, and is braced at the top by a continuous boss, which receives the overhanging arm. The arm and knee are connected with cross braces, which are readily removable. The knee is of the box section. Feeds are automatic, in longitudinal, transverse, and vertical directions, and only one can be engaged at one

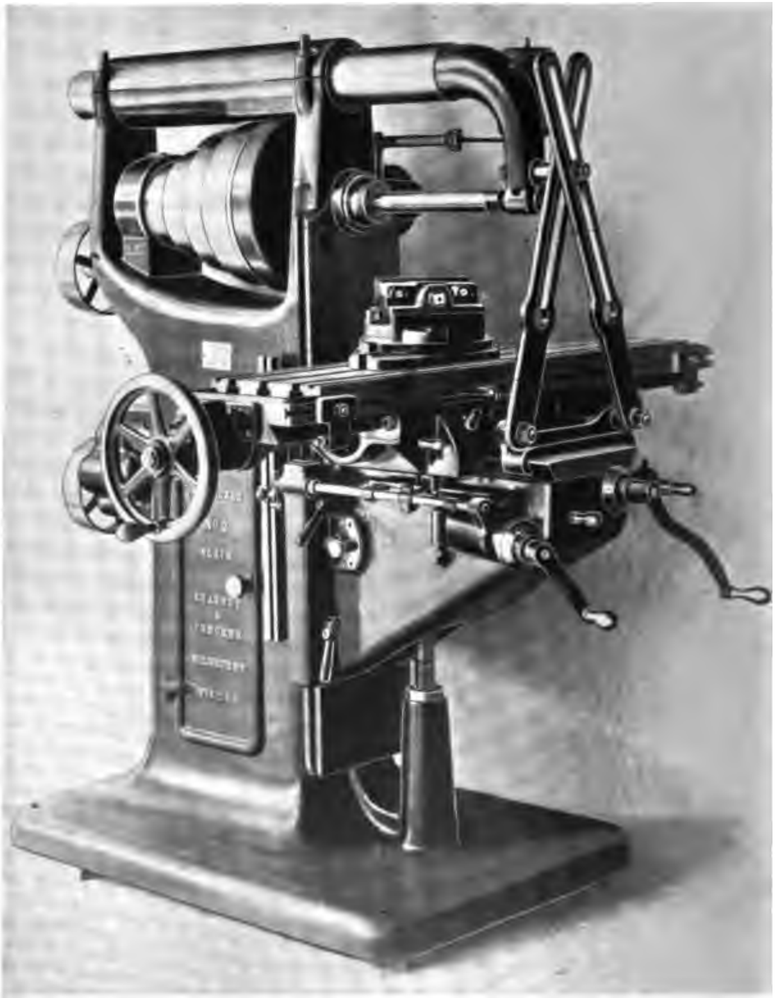


FIG. 1. NO. 2 PLAIN "MILWAUKEE" MILLING MACHINE.

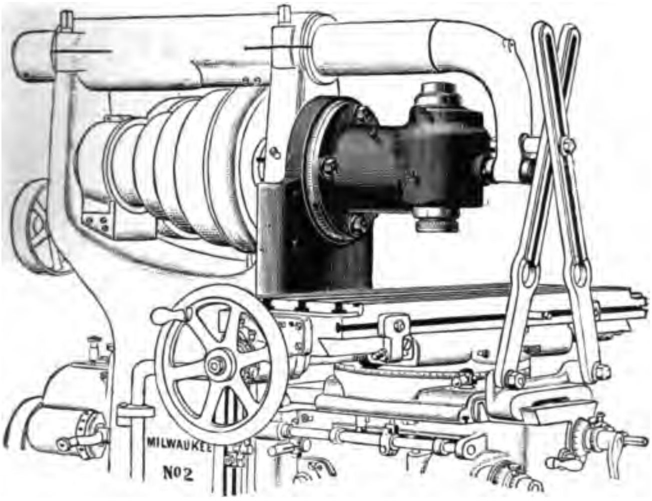


FIG. 2. VERTICAL-SPINDLE ATTACHMENT.

time, the other two being automatically locked. The feeds, twelve in number, range from ·006 in. to ·13 in. per revolution of the cutter spindle. They are controlled from a box at the rear of the machine by simply moving a lever over a dial plate, and without the employment of stepped cones. The headstock spindle has a taper hole to receive a No. 10 B. and S. taper shank, and the nose is threaded, and protected by a collar when not in use. The spindle bearings are of bronze.

In the universal machines, the spindle of the spiral head has a taper hole and threaded nose to correspond with that of the main spindle, so that all fixtures will interchange. The back centre is adjusted vertically for tapered work by means of a rack and pinion. It is graduated in degrees, to correspond with the graduations on the head, so that it is possible to set the tail centre in line with the spindle on the head instantly. The swivel carriage has a graduated circular base, and can be clamped at any angle. The thrust of the elevating and table screws is taken on ball bearings. The feed screw has compensating nuts, and all vital parts subject to wear have means of adjustment. The screws have micrometric dials, reading to thousandths of an inch.

The vertical-spindle attachment (fig. 2) is used with the arm brace still in service, so that heavy cutting is readily done. The spindle can be set to any vertical angle, and clamped there by means of the nuts in a circular tee-groove on the face of the head. The edge is graduated into degrees.

The rack-cutting attachment (fig. 3) is bolted to the same face as the vertical-spindle fitting, and is also supported by the overhanging arm. Room is left for the fitting of several cutters set parallel with each other for cutting teeth in a rack simultaneously. Spiral gears can be cut with the universal head and swivel table. In many cases a circular saw is inserted for cutting stock off to length.

NEW LATHE BY MR. GEORGE ADDY.

The photo illustrates a new electrically-driven pipe-turning and boring lathe by Mr. George Addy, of the Waverley Works, Sheffield. It is designed for dealing with pipes ranging from 10 in. to 30 in. diameter, by 12 ft. 6 in. in length. The tool is of large dimensions, weighing 15 tons, and is a striking illustration of a highly specialised machine.

Both heads are driven independently, each by its own motor, which is of the four-pole type, and therefore slow running. Instead of using a worm drive, the rotation of the motors is transmitted to the headstock gears through a pair of

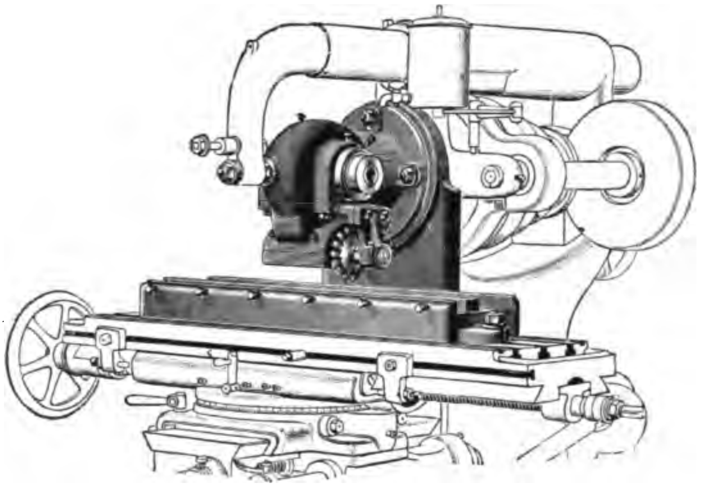
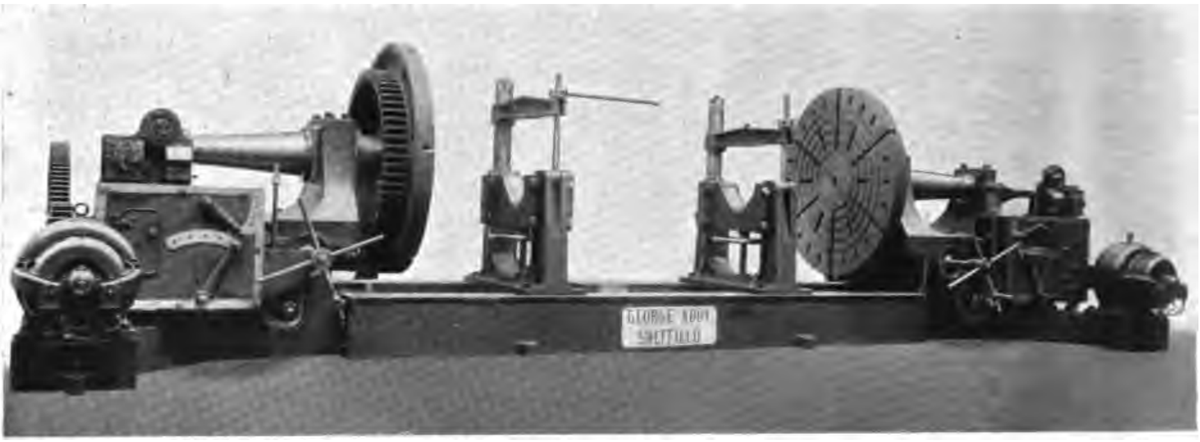


FIG. 3. VERTICAL-SPINDLE AND RACK-CUTTING ATTACHMENT.



ELECTRICALLY-DRIVEN PIPE-TURNING AND BORING LATHE. MR GEORGE ADDY, SHEFFIELD.

bevel wheels. The mechanism of each head is alike, so that a description of one will apply to both.

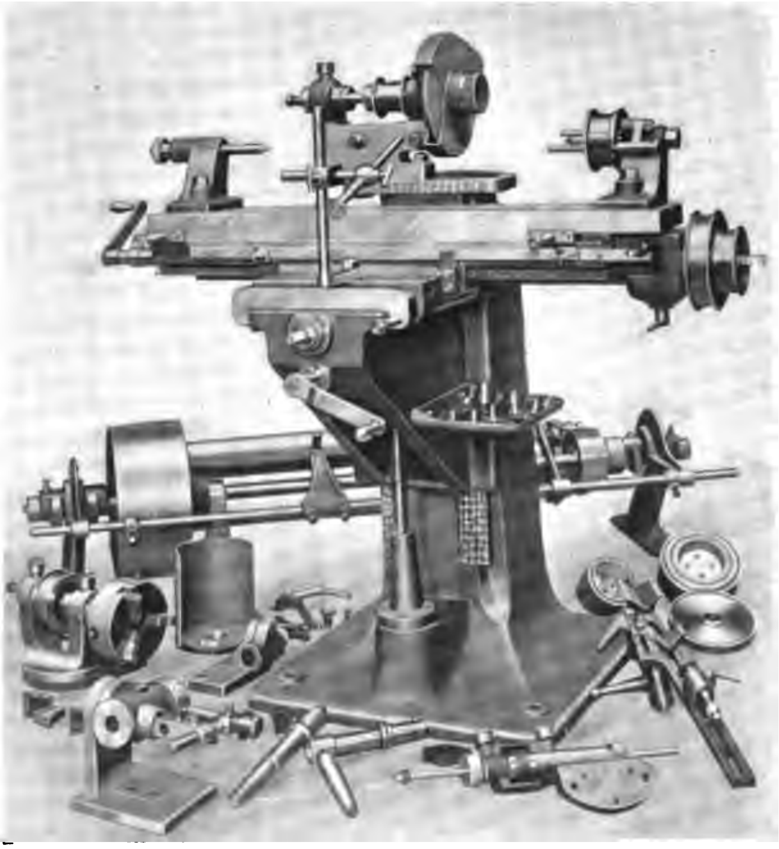
Each of the boxes seen in front of, and below, the main spindles of the headstocks, contains a nest of spur gears. The headstocks are double geared, but the back gear, placed below, is always in engagement, and variation of speed is obtained by the nest of spur wheels just mentioned. In each box there is a bottom shaft which can be slid longitudinally, and a top shaft which has no endlong motion. These shafts carry gears, and the bottom one a sliding key, by which either one of three wheels, each of a different size, is brought into engagement by the movement of the lower lever seen in front of the box, so changing the speed of the spindle, in addition to the changes afforded by the regulating switch above the box. The upper smaller lever controls the feed. This is attached through worm, bevel, and spur gearing, to a screw underneath the headstock. This can be stopped instantly by the long lever that stands up on the inside of each box, and which controls a positive clutch.

The three switches seen above each gear box are as follows. The one at the extreme outer end is the starting switch, the one above is the speed-regulating switch, or controller, and the inner one is a double-pole switch used when stopping the motor. This switch breaks the current, and so avoids having to tear the magnetic switch from its attraction; consequently it moves back as soon as the attraction has ceased.

The absence of a slide rest from this type of lathe is explained by the method of turning and boring adopted in pipe work. Cutter rings are bolted to each face plate, one of which turns the external diameter of one end of the pipe, while the other bores the internal diameter of the other end. Each headstock advances by the screw feed just now mentioned, towards the centre of the bed, until each end has been turned and bored to the required length. The face plates are grooved, so that the boring and turning heads can be bolted into position easily. The pipe rests or steadies are interesting pieces of mechanism, comprising fine screw adjustments for centres. The spindles run in bearings of gun-metal.

CRANES.

A correspondence which has been going on in a contemporary relative to electric cranes affords a striking commentary on the weakness of dogmatic assertion. Two firms, both thoroughly reliable, and fully conversant with the best modern methods, differ widely on a question of efficiency. The writer knows the works of one of these firms very well, and would be prepared to swear by any statements which they should make, so carefully are all experiments conducted there, and of so high a grade is the workmanship put into their cranes. But the point is this—experiments which are conducted in different works are not exactly comparable with each other, and the results that are obtained are very largely affected by little details of workmanship, and by local shop conditions, which are often of much greater importance than the mere calibration of instruments used in tests. Practical men will quite understand how this can happen. The writer holds that mere statements of results obtained in different shops are of little value.



UNIVERSAL GRINDING AND FINISHING MACHINE. THE LONDON EMERY WORKS COMPANY.

It is much to be desired that the whole subject of electric *versus* rope cranes should be settled in one shop on the same overhead crane, or on two cranes of similar make, fitted with motors and ropes respectively. The subject is one of much practical interest. Even now, though so many cranes are motor-driven, there are firms who still retain and prefer the rope drive, and a good business is still done in these cranes. It is true that in a vast number of cases ropes have been taken out, and the cranes converted into electrical ones, with economical results ; but in a large number of instances the rope cranes never had the chance to develop their fullest possibilities, the reason being the neglect of those precautions which experience has shown are necessary to yield the best results from the system. There is nothing perhaps more responsive to frictional losses than a high-speed rope running over a number of pulleys. If the rope is of unsuitable material, badly made or badly spliced, if the pulleys are small and not true, nor hung truly, nor of proper section, if the jockey weight is not properly proportioned, if bends are sharp, or speeds too high, the efficiency of the rope is greatly lessened, and excessive power is required to drive it. But in any case it is a rope drive.

The subject is one of more than passing interest, because the choice of power for overhead travellers is now almost entirely restricted to ropes and electric motors. The steam traveller, except for outdoor service, for which it is often very suitable, is being used less and less, while the square shaft system has many fatal objections, and is being abandoned rapidly.

FOUNDRY MATTERS—CUPOLA PRACTICE.

In England, cupola practice has not advanced so much as it has in America, nor, probably, as much as in Germany, that is if it is to be gauged by the employment of patented and improved types. In this respect the English foundryman is conservative. And yet it is open to question whether the results obtained in English foundries with common cupolas are not as economical as those obtained with the more scientific types. Of course, a very big factor always is the length of a melting, but beyond this the writer holds that almost everything depends on the skill of the melter. It is not only possible to put good iron and good coke (both ideal from the chemist's point of view) into the cupola, and obtain very bad metal, but one man will also get hot clean metal with a very much lower expenditure of coke than another. All the patents—and they are legion—which have been taken out for arrangements of tuyeres, only embody those principles with which the intelligent melter is familiar, viz., that the blast must be evenly distributed through a certain zone of the cupola, which occupies a well-defined vertical position, above and below which complete combustion and melting do not go on. Any common cupola of good height, and, with a good arrangement of tuyere holes, is capable of melting economically, if used with intelligence by a man of experience. A good bed charge is necessary, after which a comparatively small quantity of coke need be used.

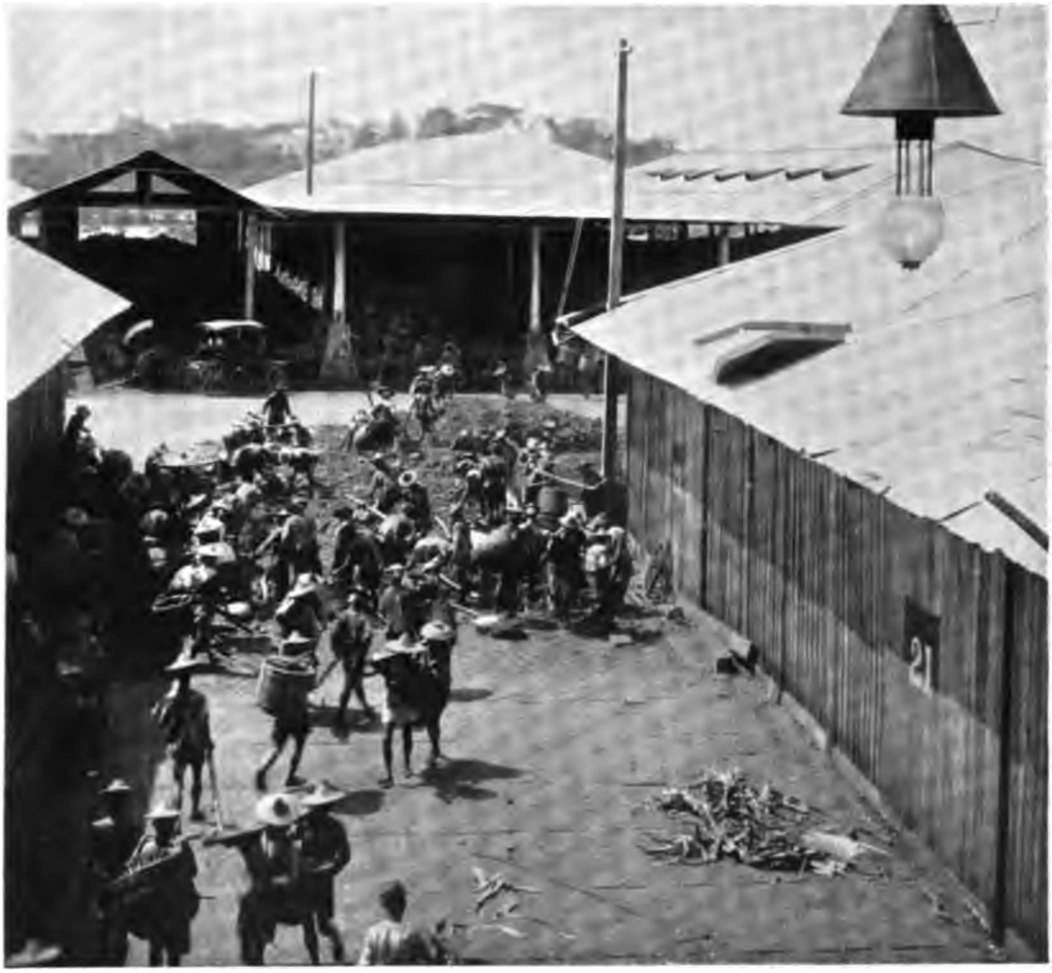
A good furnaceman is therefore a valuable acquisition in a foundry, and his wages should rate as high as those of a skilled mechanic. There is no time to idle after the metal comes down, but the melting zone must be constantly watched to see that a sufficiency of fluid iron is dropping, and the necessary instructions given for re-charging. A knowledge of chemistry alone will not ensure good results, though it helps a man in understanding the reasons for some of the phenomena which he observes daily, and is thus a valuable ally to practice.

UNIVERSAL TOOL GRINDER.

The illustration shows a universal grinding and finishing machine, with automatic longitudinal movement of table, of substantial and high-class manufacture. It is by the London Emery Works Company, of Clerkenwell, E.C. Articles which have to be ground to gauge can be handled with facility on this machine. The fitting of an automatic travel to the table gives better results than in those machines with hand travel produced by means of a crank handle. In grinding milling cutters the table does not travel the exact length of the teeth, but a little further, so that the operator has time to bring another tooth into position before grinding. Should it be necessary to work the table by hand, as is sometimes the case, the clutch on the table is brought into gear in its middle position, thus releasing the automatic feed. If the reversing pin is tightened, the return stroke can also be utilised. The grinding head is fastened to the stand of the machine and is adjustable, and either an emery wheel or a cylinder can be used. Both types are protected by a hood, to which an exhaust pipe, to draw off the dust, can be easily fitted. The machine is driven from an overhead motion, having an oscillating saddle, which gives automatic motion to the table; and the adjustment is accurately balanced with a counterpoise, so that the belting always remains taut.

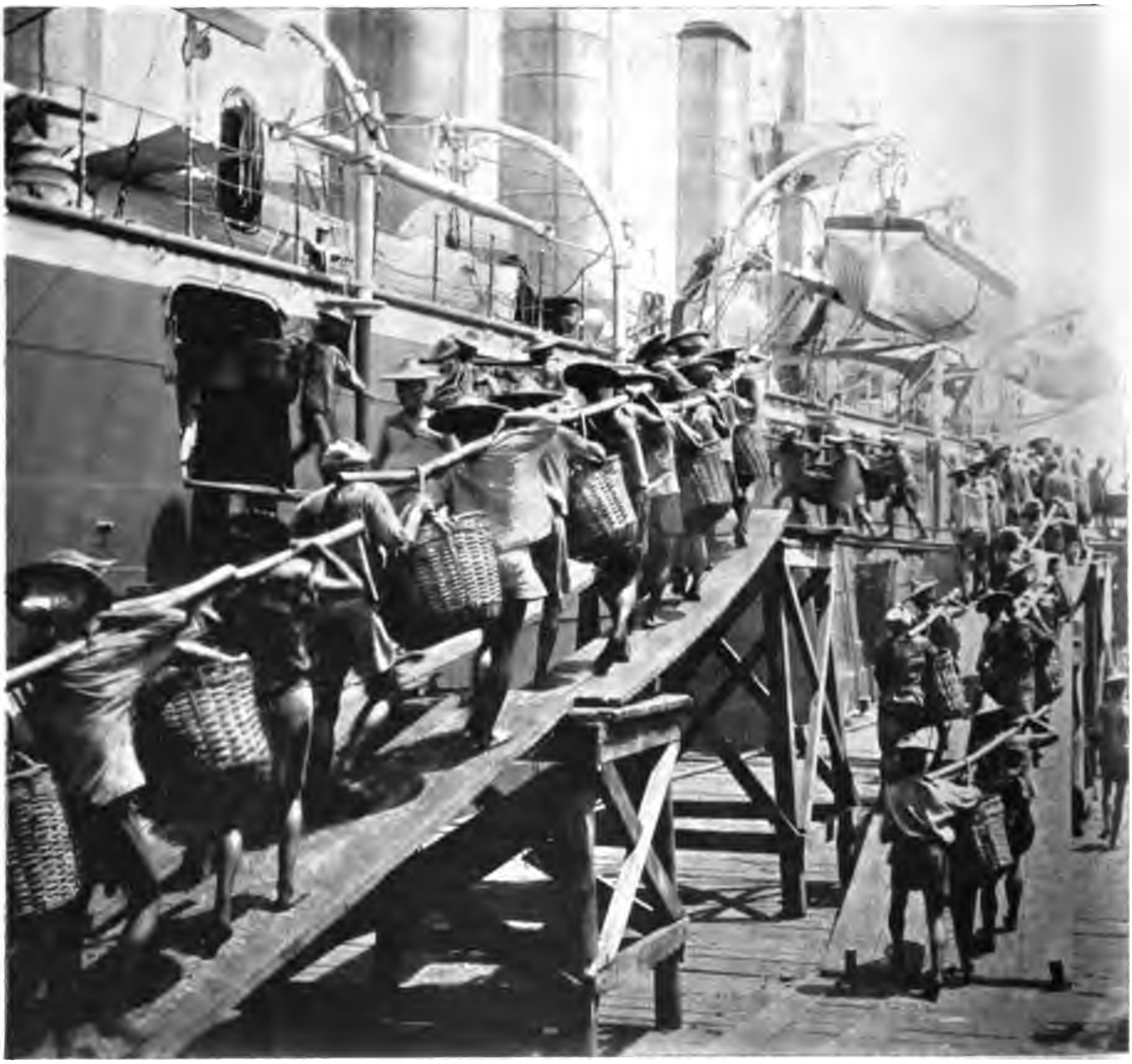
The height of the machine to the centre of the spindle is 44¾ in., the longitudinal movement of the table 23⅝ in., the traverse movement by hand 9 in., and the vertical movement, also by hand, 15¾ in. The extreme length taken between centres is 24½ in.

NOTES & NEWS.



COALING H.M.S. "TERRIBLE."

Our illustrations show the coaling of H.M.S. *Terrible* by the Tanjong Pagar Dock Company, Ltd., at Singapore.



COALING H.M.S. "TERRIBLE."

Some 1,510 tons of Cardiff coal were loaded into the *Terrible's* bunkers in 5 hours commencing at 10.7 a.m. and finishing at 3.7 p.m.—a record performance. The *Terrible* was coaled during the hottest hours of the day, the temperature in the shade being 88·3°.

10,000 Volts Three-Phase Transmission in Algeria.

Description of the Mascara three-phase transmission scheme, which utilises the falls of the river Oued-Fekan.

THE electric power transmission system at Mascara utilises power available at the falls of the river Oued-Fekan. Current is provided for the public and private lighting of the town of Mascara, which is situated about sixteen miles from the power station, and also motive power to the Mascara central pumping station, established at Side-Daho, about twenty miles from the falls.

It may be mentioned that coal averages twenty-eight shillings a ton at Mascara, and as water is also scarce, the use of steam power was practically out of the question.

A dam had to be made to retain the water at the necessary level, and its construction presented greater difficulties than all the rest of the undertaking, due to the fact that Algeria is frequently visited by terrible storms. The first dam was, in fact, swept clean away by one of these floods, and therefore the second dam has been built to withstand ten times the normal pressure. It is carried on immense concrete foundations sunk into the bed of the river to a depth of seven feet, instead of only four feet as at first, and all the masonry is built in with cement.

The head race, which commences at the dam, is about 2,000 yds. long, its width at the top being 4 ft. 2 in., and at the bottom 2 ft., and its capacity 18 cubic feet per second. It is concreted throughout its whole length, and ends in a reservoir provided with an overflow outlet. From this reservoir a steel pipe line about 490 ft. long runs to the turbines.

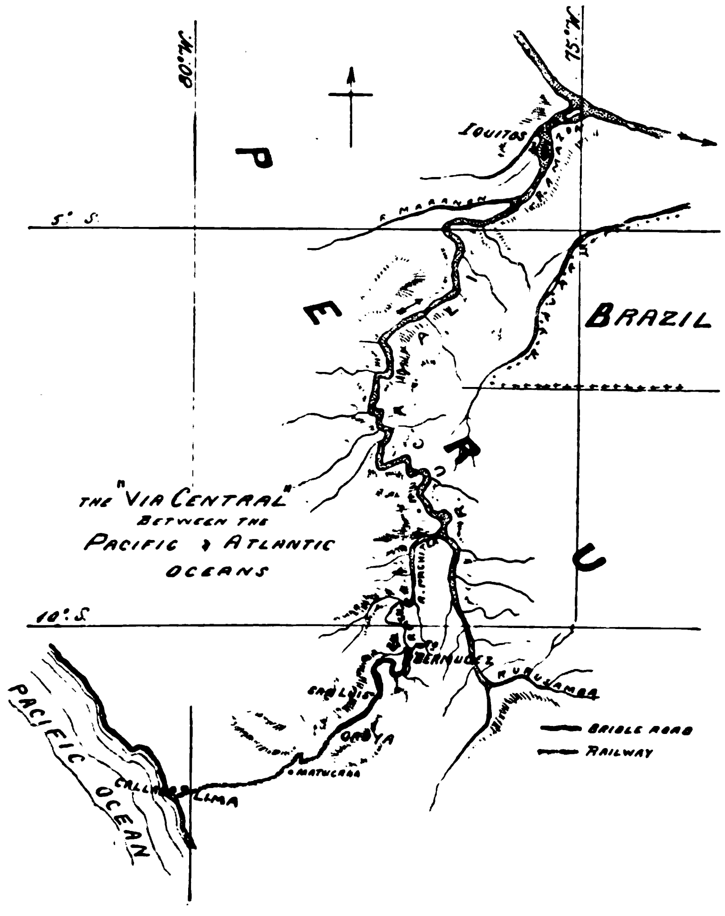
This pipe line is of rolled steel in lengths of 20 to 30 ft. each, and jointed on the Gibault system. The internal diameter is 2 ft. 3½ in., and the minimum capacity about 17½ cubic feet (110 gallons) per second, with a loss of head of 2 ft.

The effective height of the fall is 150 ft., and, in order to economise in the pipe line, the thickness of the pipe is graduated as below:—

50 ft.	$\frac{5}{32}$ in. thick	...	for	45	lb.	per	square	inch
80 ft.	$\frac{7}{32}$ in.	,,	...	,,	75	,,	,,	,,
120 ft.	$\frac{1}{4}$ in.	,,	...	,,	105	,,	,,	,,
145 ft.	$\frac{9}{32}$ in.	,,	...	,,	135	,,	,,	,,

Some of the piping is supported by iron rings fixed to massive blocks of freestone placed at convenient intervals;

ELECTRIC POWER STATION AT OUED-FEKAN, ALGERIA.



the rest is carried on tarred wooden beams so arranged that the pipe is raised a few inches above the ground.

The power station is on the left bank of the river, at a sufficient height to ensure its being above the water level during the heaviest floods. The building is 40 ft. long and 35 ft. wide. The foundations are made of hydraulic cement, concrete being also used where the presence of water necessitates this construction.

The available power amounts to about 200 h.p., and two electric generating units of corresponding output have been installed, one of them being a stand-by.

The turbines are by the firm of Negret, Bremer and Co., of Grenoble, and are of the horizontal shaft type. They are constructed for a head of 130 ft. and 20 cubic feet of water per second, and develop 192 to 200 h.p. at 500 revolutions per minute. The efficiency is 80 per cent. at full load and 72 per cent. at half load, a special turbine regulator being provided, which maintains the speed constant within two or three per cent.

The three-phase generators are of the International Electrical Engineering Company's (London) standard type, having a stationary armature and revolving field magnets, the poles (each having its own coil) being interior to the armature core. Each alternator is capable of developing 125 kilowatts at 530 volts and 50 periods per second, when running at 500 evolutions per minute. It is complete with a direct-driven exciter, and the couplings between the turbine and the alternator shaft are of the flexible type.

It may be mentioned that it was decided to generate the current at 530 volts, and to transform up to 10,000 volts, because the construction of the generators and also the switchboard is so much simplified.

Although one of the generating sets is usually held in reserve, the connections are such that both sets can be run in parallel, as, for instance, in changing over from one set to the other without stopping supply.

The transmission line consists of three bare copper conductors, each 0·3 square inch cross section. The poles are of cedar wood, 40 ft. high, and are spaced 30 to 50 yards apart.

At both ends and every 550 yards along its complete length, the line is protected by "Siemens'" lightning arresters, fitted with high-tension cut-outs.

Guard netting is employed where the line crosses the railway and the public highways. This netting is in the form of a metal cage, and it is impossible for a broken line wire to fall to the ground. Here and there conspicuous notices in both Arabic and French have been placed on the poles stating that contact with the line is fatal. A telephone line connects the generating station with the Mascara and the Side-Daho pumping works.

The receiving station at Mascara consists of an underground vault, containing four 40-kilowatt transformers, the secondary and feeder switchboards for the town lighting supply. A freezing machine has also been installed to make use of the surplus power which is available during the day time. It is on the Douane system, and is capable of producing 270 lbs. of ice per hour.

The Development of Eastern Peru.

The Camino de Pichis is a bridle-road, which is intended to serve as an outlet for the produce of a region on the eastern side of the watershed of the Andes, to which the Peruvian Government wish to attract immigrants, and is a part of the "Via Central" or "Central Route" of Peru.

This route, taken together with the navigation of the River Amazon, reaches from the Pacific to the Atlantic; but, in its present state of development at least, is not intended to afford through communication.

The upper, or western, part of the region to be developed is the hilly country, from which are derived several streams flowing into the Ucayali, chiefly those which do so as affluents of the Pachitea. This hilly part lies mostly above seven hundred metres of altitude, and the road itself rises above twelve hundred metres, from sea level. The more eastern part of the road traverses an almost level region, the banks of the Azupizú, and runs alongside that stream, and the River Pichis to Puerto Bermudez, at the confluence of the Pichis and the Chivis, about twenty kilometres north of Port Tucker.

From Callao to Oroya is 220 kilometres by rail, the latter place being 3,712 metres above sea level. Thirty kilometres beyond by bridle-road is the town of Tarma with some 8,000 inhabitants (at an altitude of 3,054 metres). Seventy-eight kilometres further north-east is the already settled valley of Chanchamayo, with the village of La Merced, which has 600 inhabitants, and an altitude of 775 metres. Cocoa, coffee, and sugar-cane are cultivated in the valley.

Thirty-four kilometres further on, and 117 from Oroya, the "Camino de Pichis" begins at the little village of San Luis de Shuaro (861 metres). This road traverses the region now advertised by the Peruvian Government, and is 221 kilometres in length, traversing a wild region which has entailed the provision by the Government of some dozen inns to provide food and shelter for the pack animals and their drivers. About 114 kilometres are in the hilly region, and the remainder in the flat land. From Puerto Bermudez, the end of this road, the journey is made by steamboat down the Pachitea and the Lower Ucayali, fifteen hundred kilometres, to Iquitos, on the Amazon, a port which ocean-going steamers can reach.

It is not quite clear whether a transhipment is necessary between Puerto Bermudez and Iquitos; if so, it could easily be avoided in the future.

The products which the "zone of the Pichis" provides or is adapted to provide, include timber, rubber, resins etc., cocoa, coffee, coca, and sugar-cane.

The journey from Lima to Iquitos is supposed to take seventeen days, the return journey being made in twenty-two days.

It should be clearly understood that this is not a through route, nor is it at present worked regularly, since the Peruvian Government, in their official guide, give the sea route, by the straits of Magellan, as the way to reach Peru from the coasts of Brazil.

This enterprise shows some activity on the part of the authorities in Peru, and the great natural wealth of the country, the remarkable extent and nature of the great waterways concerned, and the importance of some of the products of that region deserve some notice from those who are accustomed to keep an eye on the less exploited regions of the world.

Enterprise and Technical Education.

Messrs. Handyside, makers of steel bridges, roofs buildings, etc., of Derby, in order to encourage their apprentices, have arranged to pay half the fees, and purchase the necessary instruments and books, for all their apprentices who attend evening classes at the Derby Technical College, in approved subjects, for a term of three years. Apprentices who pass the prescribed examinations, will receive increased wages, and will be allowed to retain the instruments purchased for them.

In a letter to the *Times*, Mr. James D. Legard, Chairman of the Technical Instruction Committee, N.R., Yorks County Council, points out that some of the great ironmasters in Middlesbrough, and in the Cleveland district of North Yorkshire, have agreed to give their apprentices one day off in the week without counting it loss of time, and also to pay half their fees, to enable them to attend day classes in science. The county borough of Middlesbrough and the county council of the North Riding of Yorkshire have agreed to pay the other half of the fees of these pupils, who therefore are able to get this instruction free. The classes have been established by the governors of Middlesbrough High School, and are held throughout the year. The subjects of instruction include applied mechanics, practical mathematics, and steam.

It is observed that evening classes in these subjects have long been available, but it is found that after a long day in the shops, or the drawing office, a young man is hardly physically capable of taking advantage of this method of instruction. The present plan is in all ways preferable.

Successful Exhibits.

At the Düsseldorf Exhibition, the Lahmeyer Electrical Company, had some 15,000 h.p. of electrical plant running. We are informed that they received the highest award, viz., the large Gold State Medal and the Gold Exhibition Medal, for their machines in almost every group.

D. Stewart and Co. (1902), Ltd.

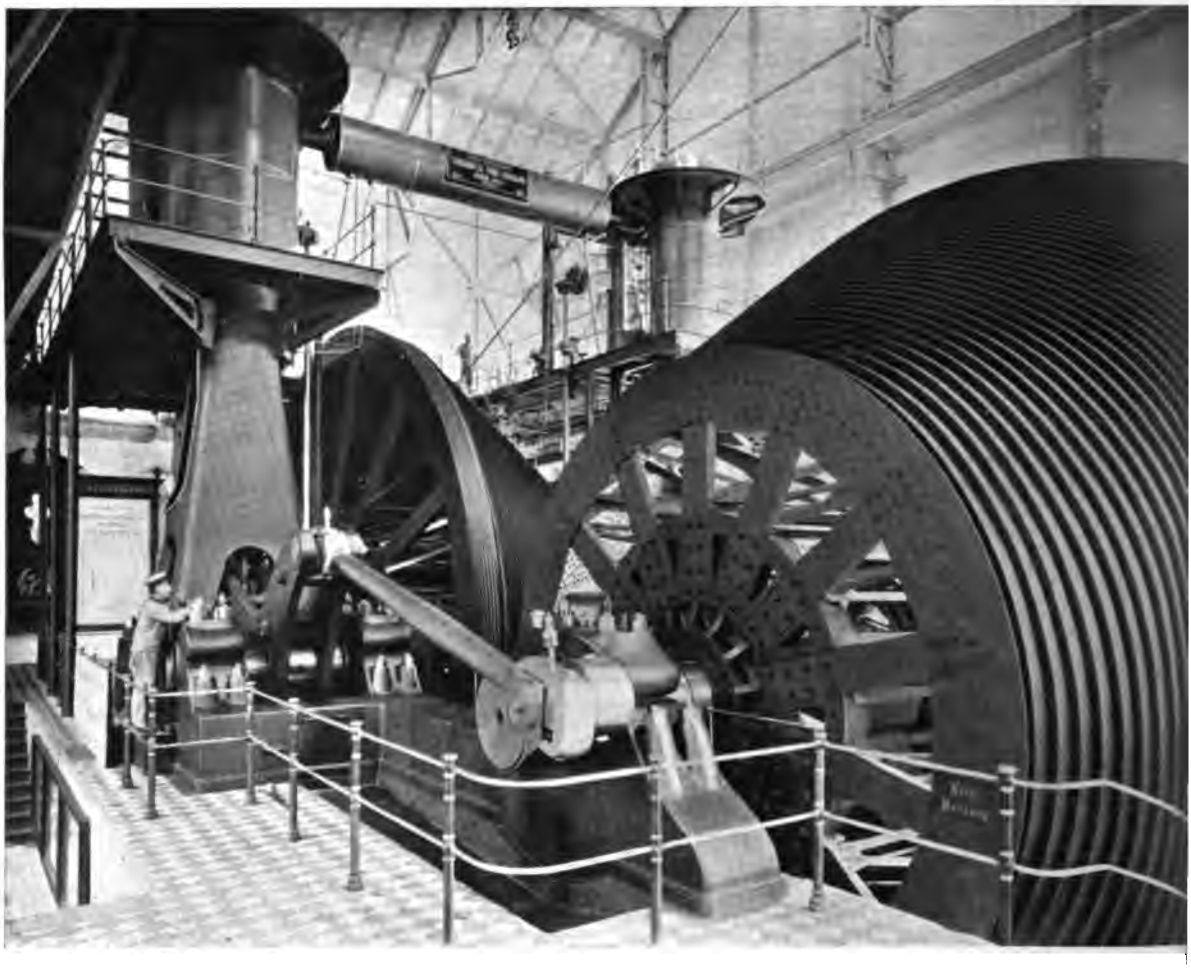
The business and works of D. Stewart and Co., Ltd., have been taken over, as at 9th June, 1902, by a new company, which has been registered under the title of D. Stewart and Company (1902), Ltd. Mr. William Beardmore, of Parkhead Forge, Rolling Mills and Steel Works, Glasgow, is Chairman of Directors.

A Notable Winding Engine.

The vertical winding engine shown in the photo was one of the most prominent exhibits at the Düsseldorf Exhibition. It was built by the Prinz Rudolf Ironworks Company, of Dulmen, for the Preussen II. colliery of the Harpener Bergbau Gesellschaft, and was designed by Dr. E. Tomson, the general manager of the Harpener Bergbau Gesellschaft. The spiral rope drums have their cones turned in opposite directions; this enabling the shafts to be kept to moderate dimensions. The engine is an inverted, vertical two-cylinder compound of the marine type, and is connected to the drums by unequal armed rocking beams and connecting rods, giving a crank throw of about two-thirds the piston stroke. The main dimensions are as follows:—

High pressure cylinder, 850 millimetres diameter by 2,600 millimetres stroke.

Low pressure cylinder, 1,150 millimetres diameter by 2,600 millimetres stroke.



VERTICAL WINDER EXHIBITED AT DÜSSELDORF EXHIBITION.

Boiler pressure, 12 atmospheres.

Diameters of drums, 5,500 millimetres to 10,000 millimetres.

Total width of each drum, 3,590 millimetres ; horizontal part, 350 millimetres wide.

Maximum winding depth, 1,200 millimetres.

Average winding speed, 10 metres per second.

With a rope speed of 12 metres per second the engine runs at 28·2 revolutions per minute, which equals a piston speed of 400 ft. per minute. The drum shafts are 650 millimetres diameter, with 500 millimetres journals, an overhanging weight being placed in the centre to counterbalance the reciprocating parts. The engine weighs in all about 470 tons, and covers some 70 ft. by 40 ft.

The loads the engine will have to wind from the various levels are as follows :—

From 800 metres, 8 tubs carrying 88 cwt. coal.
,, 1,000 ,, 6 ,, ,, 66 ,, ,,
,, 1,200 ,, 4 ,, ,, 42 ,, ,,

giving an hourly output of 180, 145, and 125 tons respectively, twenty seconds being allowed for decking. The pit-frame, some 109 ft. high, which is to be used with this engine, was also shown at the exhibition, and was built by the Humboldt Engineering Works Company, of Kalk. The cages weigh 4 tons, and the rope about 10 tons, giving, with eight loaded tubs, a load of 18 tons 8 cwt. from the bottom. The pit-frame has Tomson's improved method of changing all four decks at once on to hydraulic-balanced cages, these cages being discharged during the next winding.

New Destructor Plants.

Orders for a destructor plant, to deal with 120 tons of refuse per day, have been placed with the Horsfall Destructor Company, Ltd., by the Bradford Corporation. The same company is also providing destructor plants for Swansea and West Hartlepool, to deal with 75 and 60 tons respectively per diem. The West Hartlepool plant is an extension of the existing " Horsfall " destructor.

NAVAL NOTES.

MONTHLY NOTES ON NAVAL PROGRESS IN CONSTRUCTION AND ARMAMENT.

BY

N. I. D.

THE two questions of the greatest interest which have concentrated the attention of naval students during the past month are those which concern the share which the Colonies are prepared to take in the provision of Imperial defence, and the future training of the naval officer. With regard to the former, the proceedings of the Colonial Conference, which have now been issued, are full of the most interesting matter, some portion of which I propose to refer to here. On the other hand it is somewhat difficult to deal, except in the most cursory manner, with the second and equally important problem—that connected with the supply and training of officers for the Navy.

It is generally known at the time of writing that the Admiralty have in contemplation large changes connected with the entry and the co-ordination of the various branches of officers. It may be that the official scheme will be made public before these lines appear; for the present everything is a matter of conjecture and speculation. What we may be quite sure of is that the Board, with Lord Selborne at its head, will have given due consideration to the vastness and complexity of this question, so intimately associated with the future prosperity of the Navy and the Empire. We have heard a great deal about the grievances of the marine engineers, the officers in charge of the engineering department of the Navy. Other branches, too, have at various times voiced their aspirations and desires. We may rest assured that any scheme which has for its basis merely the gratification of such desires, or the remedy of such personal complaints, cannot be an adequate solution of the problem. What is wanted is something conceived in a more statesman-like frame, something showing a broad-minded grasp of the essential necessities of the nation's Navy. Such legislation must be, for the future, tempered by tactful treatment of existing personal and professional feelings and sentiments. A common entry (preferably by nomination), a common educational basis of culture, a common *alma mater*—these things will tend to remove distinctions and jealousies which have existed in the past. Upon such a foundation we may build up a technical education such as the scientific improvements and developments of to-day imperatively demand, while conserving all that portion of the training which the experience of generations demonstrates as essential to the production of the self-reliant, responsible, and resourceful seaman of to-day.

In this connection I may quote from the speech of that ardent reformer and capable public servant, Mr. Arnold Forster, the Financial Secretary to the Admiralty, who, speaking at the Guildhall Banquet on November 11th, said:—

> He honestly believed that in no department of the State was a higher and nobler quality of service rendered than in the Navy. If he were asked in what he thought the chief and most excellent distinction of the naval service lay, he would say that it was in the traditions of thoroughness of work, of zeal displayed without the stimulus of immediate reward, or the desire for public approbation; and, above all, in the extraordinary loyalty of naval officers to their own service, and the wholesome feeling of comradeship which made every officer speak well of his brother, and dwell rather on his merits and successes, however small, than upon his faults and failures, however marked. He thought it was impossible to exaggerate the value of those traditions, and of this he was certain, that any change which tended to diminish their force or to discount their value would be disastrous to the Navy and to the country which it served. Changes there must be from time to time, but he believed the Admiralty was fully alive to the truth that no change which failed to take into account the best feelings and traditions of the Navy, and which did not seek to extend their enjoyment to all who served in the fleet, could be a wise one, or beneficial to the service.

One of the most important results, from a naval point of view, of the recent Colonial Conference is that an increase in the number of modern men-of-war maintained in commission will have been promoted by the aid of British subjects in the dominions beyond the seas. There is also a larger and wider appreciation throughout the Empire of the peculiar characteristics of naval warfare, and of the fact that those local considerations, which find their natural place in military organisations, are inapplicable to naval organisation. And, further, we have the establishment of a branch of the Royal Naval Reserve in the Colonies, notably in Newfoundland. In Australia and New Zealand a great step has been made in connection with the matter, for it has been agreed that if possible one of the ships of the Australian squadron in permanent commission shall be manned by Australians and New Zealanders, under officers of the Royal Navy, and that ten cadetships in the Royal Navy shall be given annually in Australia and New Zealand. Perhaps the most important document which is to be found in the papers relating to the Colonial Conference is a memorandum which has been prepared by the Admiralty on sea power and the principles involved in it. This memorandum I recommend to the attention of the readers of these Notes. The following points may be said to contain the keynote of our naval policy in its connection with Imperial defence:—

> The importance which attaches to the command of the sea lies in the control which it gives over sea communication. The weaker sea Power is absolutely unable to carry to success any large military expedition over sea. The truth of this is shown by reference to the history of the past. On the other hand, the advantages which accrue to the stronger sea Power, after it has won the command of the sea, are equally illustrated by historical example. The command of the sea is determined by the result of great battles at sea.
>
> To any naval Power the destruction of the fleet of the enemy must always be the great object aimed at. It is immaterial where the great battle is fought, but wherever it may take place, the result will be felt throughout the world, because the victor will afterwards be in a position to spread his force with a view to capturing or destroying any detached forces of the enemy, and generally to gather the proofs of victory, in the shape of outlying positions in his possession, his shipping and commerce, or even to prosecute over-sea campaigns.
>
> Stress is laid on the importance of the great battle for supremacy, because the great development of the navies of France, Germany, the United States, and Russia, indicates the possibility that such battles may have to be fought in the future. It is the battleships chiefly which will have to be concentrated for the decisive battle, and arrangements must be made with this object during peace
>
> Our possible enemies are fully aware of the necessity of concentrating on the decisive points. They will endeavour to prevent this by threatening our detached squadrons and our trade in different quarters, and thus obliging us to make further detachments from the main fleets. All these operations will be of secondary importance, but it will be necessary that we should have sufficient power available to carry on a vigorous offensive against the hostile outlying squadrons, without unduly weakening the force concentrated for the decisive battle, whether in Europe or elsewhere.
>
> The immense importance of the principle of concentration, and the facility with which ships and squadrons can be moved from one part of the world to another, points to the necessity for a single navy, under one control, by which alone concerted action between the several parts can be assured.
>
> In the foregoing remarks the word defence does not appear. It is omitted advisedly, because the primary object of the British Navy is not to defend anything, but to attack the fleets of the enemy, and, by defeating them, to afford protection to British dominions, shipping, and commerce. This is the ultimate aim. The traditional *rôle* of the British Navy is not to act on the defensive, but to prepare to attack the force which threatens—in other words, to assume the offensive. The strength and composition of the British Navy, or of any British squadron, depends, therefore, upon the strength and composition of the hostile forces which it is liable to meet.

It would be most unfortunate if the idea should prevail that the problem is one of local defence, and that each part of the Empire or each coast town, whatever might be its importance, can be content to have its allotment of ships, for the purpose of the separate protection of an individual spot, the result of which could only be disastrous. Both at home and in the Colonies it is necessary to arouse a sense of personal interest and of personal possession in the Imperial Navy—a feeling that the protection of our interests, our commerce, and our dominions is an affair of ocean strategy, not one of stationing ships here and there to soothe the apprehensions of every coast town that may seem open to attack. As Lord Selborne has said, the sea is all one, and the British fleet must be all one, controlled by one authority with full power, and full responsibility, guided by but one idea—that the task of the Navy in war time must be to seek out the ships of the enemy wherever they are to be found and to destroy them.

GREAT BRITAIN.

Another of the battleships of the programme of 1898-1900 has now made her trials. This is the *Duncan*, which was built by the Thames Shipbuilding Company and was delivered at Chatham to be completed. During her full-power trials, the mean speed on five runs on the measured mile was 19·11 knots. On that occasion the draught of water forward was 26 ft. 2 in. and aft 26 ft. 11 in. The steam pressure in the boilers was 291 lb. per square inch, and the vacuum in the starboard condensers was 25·4 in., and in the port condensers 26·5 in. The starboard revolutions were 120·5, and the port revolutions 121.1 per minute. The starboard engines had an i.h.p. of 9,196, and the port 9,036, a total i.h.p. of 18,232, with a speed by patent log of 18·9 knots. The *Duncan* is now to be prepared for commission at once.

Information has been published in reference to the makers of the engines and boilers of most of the ships for the 1901-03 programmes. Some of this information has already appeared in these Notes, but it may be as well to give it as a whole. Of the five battleships, the *King Edward VII.*, building at Devonport, will have her machinery supplied by Messrs. Harland and Wolff, and her boilers will be four-fifths Babcock and Wilcox and one-fifth cylindrical; the *Commonwealth*, building by the Fairfield Company, will have her engines made by the same firm, and will be supplied with Babcock and Wilcox boilers. The *Dominion* is to be supplied with machinery by her builders, Messrs. Vickers, Sons and Maxim, and will also have Babcock and Wilcox boilers. The *New Zealand*, to be built at Portsmouth, will have her machinery supplied by Messrs. Humphrys, Tennant and Co., and will have four-fifths Niclausse boilers and one-fifth cylindrical; the *Hindustan* will have her machinery supplied by the builders, Messrs. John Brown and Co., and will have four-fifths Babcock and Wilcox and one-fifth cylindrical boilers. Some interesting details about the fittings of these boilers were given in our Monthly Résumé for November. All these five battleships will have a displacement of 16,500 tons, and a speed of 18·5 knots, the engines being of 18,000 i.h.p. The vessels will be armoured throughout, the heavier guns consisting of four 12-in. pieces, carried in pairs in turrets fore and aft. The secondary armament of ten 6-in. guns will be enclosed in a central battery, separated by armoured screens, but not placed in casemates. Each vessel will have, however, four 9·2-in. guns mounted in turrets at the four upper angles of the citadel, two having a forward fire and two a fire aft. These vessels will therefore be able to fire right forward with two 12-in., two 9·2 in. and two 6-in. guns, and the fire astern will be similarly formidable.

In the Naval Notes for last month the manner in which the armoured cruisers of the *Devonshire* class are to be boilered was described. The machinery of these vessels will in three cases be supplied by the builders; but the *Devonshire* will get her machinery from the Thames Ironworks Company, the *Carnarvon* from Messrs. Humphrys, Tennant and Co., and the *Hampshire* from Messrs. Hawthorn, Leslie and Co. In regard to these six vessels it is officially stated that their armour was provisionally ordered on August 18th last, and the orders were confirmed on September 3rd, the manufacture of the armour being commenced, therefore, just eighteen months after it was announced that the vessels would be built.

Of the two armoured cruisers of the 1902-03 programme, one is to be built at Pembroke and the other by contract. Specifications for the latter have been sent to the shipbuilders. These vessels will have a displacement of 13,000 tons. They are to carry 9·2-guns, and the anticipated speed is 22 knots, obtained with engines of 24,000 i.h.p.

In a previous issue we referred to four vessels of a new class and type, which were included in the 1902-03 programme. When destroyers were first designed, it was not contemplated that they would be frequently used otherwise than as working from a fixed base. Experience, however, has shown that vessels with greater sea-keeping power are required for service with fleets, and the new vessels will therefore have a separate and distinct function, that of acting as scouts. Their armament will enable them to deal with destroyers, or other small craft with which they may come in contact, but they are not intended to fight heavier vessels, the importance of carrying their news being deemed to outweigh the value of a victory. The private shipbuilders of the country were invited to submit designs for these vessels, and, subject to certain modifications, orders have now been placed for four of them. One, to be built by Elswick, will have her machinery supplied by Sir W. G. Armstrong, Whitworth and Co., and will be provided with modified boilers. A second will be built by the Fairfield Company, who will also supply her machinery, the boilers being of the Fairfield small water-tube type. A third will be built and engined by Messrs. Vickers, and supplied with Vickers' Express boilers. The fourth will be constructed by Messrs. Laird Bros., the machinery being supplied by the same firm, and the boilers being of the Laird-Normand type. The coal carried at the normal displacement is 165 tons, but the full supply will run to 380 tons, which, at a speed of from ten to twelve knots, should give them a radius of action of about 3,000 miles. They will be built of sufficient length, and will be provided with forecastles, thus ensuring good sea-keeping capacity. They are designed to maintain the guaranteed full speed of 25 knots under ordinary conditions of weather. The armament comprises six 12-pounder quick-firing guns—two on the forecastles, two aft, and two amidships; eight 3-pounder quick-firing guns—four on each broadside; and two 18-in. above-water torpedo-tubes. [illegible] will be afforded by a steel deck, varyi[illegible]ness from ⅝ in. to 1½ in., worked into t[illegible] from end to end, and sloped so that the outer edge falls below the normal water-line. The exact dimensions of these vessels and their tonnage appear to be uncertain, but they will probably be about 350 ft. in length and have a displacement of between two and three thousand tons.

FRANCE.

The French Naval Budget for 1903 has been laid before the Chamber. The total amount is the same as that for the previous year, namely, 306,798,738 francs. There is a diminution of expenses for the maintenance of squadrons at sea and for the Admiralty, but there is a large increase in the charges for new construction, particularly for work in private yards. There is also an increase in the sum required for naval works. The reduction in the charges for the fleet at sea follows from a new arrangement by which the squadron is supplied with reduced complements. This plan has already been tried in the Northern Squadron, and it is now being adopted in the Mediterranean, much against the advice of French naval officers.

In reference to the charge brought against M. Pelletan, of delaying the construction of some of the principal ships, such as the *Patrie*, *Justice*, *Liberté*, and *Verité*, the Minister of Marine has explained to the Budget Committee that his reason for countermanding the construction of these battleships was that naval expenditure had already exceeded the estimates by 15,000,000 francs, and that a similar discrepancy might be expected next year. He urged the impossibility of ordering constructions for which the money had not been voted, but assured the Committee that the work on the two battleships at Nantes and Bordeaux would not be suspended. With regard to the *Republique*, the type of boilers with which she is to be supplied has not yet been decided; but as this vessel is not to be finished until 1906 there is plenty of time for making a decision before then. It is not intended to make any change with regard to her armament.

As regards armoured cruisers, the *Ernest Renan*, a sister-ship to the *Jules Michelet*, is under construction at St. Nazaire; but it stated that her plans are to be completely arranged, with consequent loss of time. This delay in the completion of the programme has also given rise to a protest against the policy of M. Pelletan.

Rear-Admiral Dupont, writing in the *Gaulois*, very harshly criticises the recent creation of a body of administrators of the Inscription Maritime. Thus, he says, is formed a corps of civil functionaries who will be the creatures of the Ministry, and will end by being a burden to the taxpayers. In other quarters it is alleged that a state of chaos reigns in the Rue Royale.

As regards the submarines, M. Pelletan has stated that he is not in favour of reducing their tonnage, although he believes with Admiral Aube that boats of 30 tons would be useful in certain circumstances. He is in favour of increasing the size of these boats where a large radius of action is essential, but orders for larger vessels cannot be given until the most suitable types have been decided upon. There has been much delay in the construction of the thirteen submarines, and the building of others has been greatly retarded. It is alleged that there are at present twenty submarines in course of construction at Cherbourg, Rochefort, and Toulon. These were ordered in April, 1901, and should have been ready for trials at the end of this year, but owing to the delay in ordering the electric accumulators which supply the motors, the craft will not now be ready.

The experiment of launching the *Kleber*, fully equipped with her masts, guns, engines, and boilers in place, is stated to have been most unsatisfactory, and calculated to lead to further expense. It is feared that, owing to the tremendous weight, the sides of the vessel have been badly strained, and the whole construction weakened.

GERMANY.

The delivery trials of the new battleship *Wettin* were satisfactorily accomplished in August. The vessel has a displacement of 11,900 tons, and, with an i.h.p. of 15,000, has developed a speed of 19 knots. The construction was undertaken by Schichau, of Dantzig, and only occupied thirty-four months. In this connection a rather interesting comparison is given in the *Marine-Rundschau* of the time taken to build the ships of the *Kaiser* class, which have a displacement of 700 tons and engines of 21,000 i.h.p. less than the *Wettin*. The *Kaiser Wilhelm II.*, built at the Imperial Yard, Wilhelmshaven, took forty-one months to build; the *Kaiser Wilhelm der Grosse*, at the Germania Yard, Kiel, took thirty-nine months; the *Kaiser Karl der Grosse*, built by Bruhm and Boss, of Hamburg, also took thirty-nine months; and the *Kaiser Barbarrossa*, built by Schichau, took thirty-three months to construct. At the trials of the *Wettin* in October some trouble occurred owing to the giving way of the supports for the heavy guns, and the vessel had to return to port for repairs. It is stated that the *Wittlesbach Zahringen* and the *Wettin* will be commissioned early next year, and that as the remainder of these ships hoist the pennant the ships of the *Brandenburg* class will be withdrawn in order to go through a similar process of modernising to that which the *Worth* is already undergoing at Wilhelmshaven.

The new division of deep-sea torpedo-boats, building by Schichau at Elbing, is so far advanced that the first boat is now ready for commission. These boats will be numbered S114 to S119. Another similar scheme of construction is to be put in hand next year, but the building and cost of these will figure on the programme for 1904.

RUSSIA.

Progress has been made upon several of the smaller cruisers of the Russian Navy. The *Boyarine*, launched at Copenhagen on June 8th, 1901, is to be delivered to the Russian authorities immediately. The *Otchakoff*, building at Sevastopol, was launched on October 4th, in the presence of the Tsar. Her dimensions are as follows: Length over all, 439 ft. 7½ in.; length on the water-line, 433 ft. 5½ in.; beam, 54 ft. 5½ in.; draught, fully loaded, 20 ft. 7½ in.; displacement, 6,570 tons. The engines are of 19,500 i.h.p., and will be supplied with steam by sixteen Normand boilers. The speed anticipated is 23 knots. The normal bunker capacity is 720 tons, the full capacity 1,100 tons. The thickness of the armoured deck will vary from ¾ in. to 2¾ in., and her casemates will be protected by 3½-in. and her turrets by 5-in. plates.

The armament will consist of twelve 6-in. guns, four in turrets, four in casements, and four with shields; twelve 2·95-in. guns; six 1·85-in. guns; and two submerged torpedo-tubes. She was begun on March 7th, 1901.

The *Alma*, building at the Baltic Yard, St. Petersburg, recently had the ceremony of the *Zakladka* performed on her by the Tsar. This consists in the placing of a silver plate or tablet, and only takes place after a considerable portion of the ship's hull has been armour-plated. The *Alma* was laid down on May 6th last year, and the ceremony of the *Zakladka* took place on September 25th. The dimensions of the vessel will be as follows: Length over all, 363 ft.; length between perpendiculars, 325 ft.; beam, 43½ ft.; draught, 17½ ft.; displacement, 2,385 tons. The engines, of 7,500 h.p., will be supplied with steam by sixteen Belleville boilers, the anticipated speed being 19 knots, and the normal coal capacity 560 tons. The armament will consist of 2·95-in. and 1·85-in. guns.

The *Kniaz Souvaroff* battleship, which was laid down in September, 1901, was launched in the presence of the Tsar on September 25th, at the Baltic Works, St. Petersburg. The length of this vessel over all is 398 ft.; between perpendiculars, 367½ ft.; beam, 76 ft.; draught, 26 ft.; and her displacement is 13,516 tons. The engines, of 15,800 i.h.p., are to be supplied with power from twenty Belleville boilers, and the anticipated speed is 18 knots. Her normal coal capacity is 1,250 tons. On November 1st the Tsar also performed the ceremony of *Zakladka* on the battleship *Slava*, at the Baltic Yard, St. Petersburg. She belongs to the same class as the *Kniaz Souvaroff*, the *Alexander III.*, the *Borodino*, and the *Orel*.

The *France Militaire* states that the official trials of the armoured cruiser *Bayan* took place at Toulon on October 28th. The engines developed 17,400 i.h.p., and the speed attained was 21 knots, the trials being considered satisfactory.

JAPAN.

It has been announced from Yokohama that a new programme of naval construction has been decided upon, to extend over a period of six years. It is said that the scheme will involve an annual expenditure of about £2,000,000, the total expenditure reaching £12,000,000. Four battleships, six armoured cruisers, and several smaller vessels are comprised in the programme, and the whole will have an aggregate displacement of 120,000 tons. It is stated that the four battleships will be built in England, the cruisers in France, Germany and England, and the smaller vessels in Japan. It is also reported that the carrying out of the scheme adopted is to be spread over ten years, from 1904, and will provide only for three battleships, three armoured cruisers, and two smaller vessels.

AUSTRIA-HUNGARY.

The trials of the Austrian battleship *Hapsburg*, which recently took place at Pola, were interesting, inasmuch as the results obtained constitute, it is believed, a speed record for vessels of similar class and displacement. The *Hapsburg* is the first vessel of the class completed by the Austrian Government, her sister ships the *Arpad* and *Babenberg*, being now in course of construction. The following are the leading dimensions of the vessel, machinery, and armament: Displacement, 8,340 tons; length between perpendiculars, 350 ft.; beam, 65 ft.; mean draught, 23 ft. 3 in., area of midships section at above draught, 1,324 square feet. The propelling machinery is of the twin-screw triple-expansion type, with inverted engines, having four cylinders arranged in manner similar to those fitted on board British first-class cruisers: High-pressure cylinders, diameter, 29·9 in.; mean pressure, 43·8 in.; low-pressure (2), 56·3 in., with a uniform stroke of 37·4 in.; total cooling surface of the condensers, 15,000 square feet; estimated revolutions at full power, 135 per minute; propellers, four-blade type, 16 ft. in diameter, having mean pitch of 16 ft. The steam-generating plant consists of sixteen Belleville boilers of the economiser type, similar to those recently fitted to the battleships and cruisers in our Navy, having a total heating surface of 30,300 square feet and grate area of 864 square feet; the working steam pressure at boilers is 300 lbs., and reduced by automatic valve to 250 lbs. at main engines. The total weight of machinery complete is 1,098 tons. The vessel is protected by means of an armour belt for over 60 per cent. of its length, the spaces beyond being covered by heavy armoured deck; total weight of armour carried, 2,250 tons. The artillery consists of three 24-centimetre Krupp guns 40 calibres in length, twelve 15-centimetre quick-firing guns 40 calibres in length, and twenty-four quick-firing guns of smaller calibre. The coal capacity is 800 tons, which, at a speed of 12 knots, provides for steaming a distance of 3,600 knots. The conditions of trial were that a mean power of at least 11,900 horse-power should be maintained, and the vessel should be propelled at a mean speed of 18½ knots. The speed of the ship was to be taken during the full-power trial, over a carefully-measured course having a total length of 68 knots. The actual results obtained were as follows: Mean pressure at boilers, 285 lbs.; mean pressure at high-pressure receivers, 224 lbs.; mean revolutions, 141·47 per minute; vacuum, 26 in.; indicated-horse-power, 14,942; mean speed for total distance of 68 knots, 19·62 knots.

ARGENTINA.

The armoured cruiser *Rivadavia*, of the *Garibaldi* type, was launched at Messrs. Ansaldo's yard at Sestri Ponente on October 22nd. At the ceremony, Signor Soliano, of the Ansaldo firm, stated that the new cruiser is not a copy of the *Garibaldi* and the *Cristobol Colon*, but a considerable improvement upon them. Her displacement is about 7,500 tons, and her speed 20 knots. This cruiser and another, building at the same yard, were originally named the *General Roca* and *General Mitra*, they are now to be named the *Bernardino Rivadavia* and *Mariano Moreno*.

SPAIN.

A committee has been appointed to consider the proposals to build what will practically be a new Spanish fleet. The programme consists of ten battleships, of 13,000 tons; six to ten cruisers, of 3,000 tons, six torpedo-boat destroyers, thirty torpedo-boats, twenty gun-boats, and some other vessels. The cost of building these vessels would be from twenty to twenty-four million pounds sterling, and the cost of their up-keep would raise the annual charge for the Navy to between three and four millions. It is stated that the cruisers *Marques de la Ensenada* and *General Valdes* have been condemned as ineffective, and are to be used for torpedo practice.

UNITED STATES.

The battleship *Maine* has at last been accepted by the Navy Board, after a revision of the report of her trials, when it was discovered that she had just attained the desired speed of 18 knots. The Board state that the working of the machinery, both main and auxiliary, was satisfactory.

Bids for the construction of the largest battleship ever projected by the United States Navy have been accepted from the Newport News Company with a bid of $3,990,000. This vessel will be named the *Louisiana*, while her sister ship the *Connecticut*, will be built at a navy yard. These vessels were more fully described in our October issue.

A dispute which arose among the members of the Navy Board about the construction of the armoured cruisers of the *Tennessee* class has been settled by the decision of the Board of Construction to reduce the weight of machinery in these vessels from 2,250 tons to 2,060 tons. The speed is not to be less than 21·5 knots, and the h.p. is to be 23,000. The vessels of this class will therefore be shortly put in hand when the contracts have been decided upon. It is estimated that these vessels will represent, when in commission, an expenditure of $6,000,000.

The annual report of the Chief Constructor of the United States Navy shows that the progress made upon the ships in hand has been far from satisfactory. The battleship *Nebraska*, building at Seattle, and the three armoured cruisers *California*, *Milwaukee*, and *South Dakota*, now building at San Francisco, have been delayed by the non-delivery of steel consequent upon the strikes. The battleships *Missouri* and *Ohio*, and the four monitors, *Arkansas*, *Florida*, *Nevada* and *Wyoming*, have also been delayed, chiefly owing to the inability of the contractors to supply the armour.

The cruiser *Des Moines*, which was launched from the yard of the Fore River Ship and Engine Company, Quincy, Mass., on September 20th of this year, is progressing rapidly.

THE "FUEL" VALUE OF TOWN REFUSE.

BY

ED. C. DE SEGUNDO, A.M.INST.C.E.

The author in this article advances the argument that a Refuse Destructor must be looked upon as a necessary sanitary appliance, and not as a money-earning machine. Nevertheless, the combustion heat of refuse may, within reasonable limits, be profitably applied even for purposes requiring a steady boiler pressure.—EDITOR.

THE disposal of refuse can be looked at in two ways, namely, from a purely hygienic point of view, or from what might be termed a utilitarian point of view. As long ago as the year 1888 the subject of refuse disposal in towns and cities had forced itself sufficiently upon the attention of the authorities to warrant an investigation of the whole matter by the Local Government Board. Colonel Thomas Codrington was instructed to report upon the subject, and in the course of time presented a report which was not only highly interesting and instructive, but also contained some valuable information upon what has recently become a bone of contention amongst certain engineers, namely, the calorific value of dust-bin and other refuse. The average composition of refuse, as set forth in Colonel Codrington's report, should be conclusive evidence to any impartial minded person that the only thing to be done with refuse is to burn both it and its products of combustion in such a way as to render it absolutely innocuous, and no doubt Colonel Codrington's investigations did very much to bring into prominence what is known as a "Refuse Destructor." It is not a very happy title for this apparatus, but in spite of other suggested words the word "Destructor" seems to have stuck to any apparatus—the object of which is to destroy refuse by burning.

BURNING *VERSUS* TIPPING.

The investigations of other engineers have placed beyond any doubt that the crude methods of dealing with the refuse of towns and cities amount in some instances to culpable negligence on the part of the authorities. Mr. Francis Goodrich, in a recent article on this subject, drew attention to what he rightly termed a glaring example of improper refuse disposal in the Isle of Wight, near Osborne. It appears that about three miles from Osborne House, and literally only a few yards from a road, there is a heap of refuse which has been tipped on this spot for years past. In another article on this subject, Mr. Goodrich draws attention to the fact that over eight hundred towns and villages in England and Wales alone, with populations of 2,000 inhabitants and upwards, still tip their refuse, and appear to be absolutely apathetic to the risks incurred thereby. On the outskirts of a large and important town in Ireland is to be found a heap of decomposing refuse in such a condition that its removal would be not only a matter of considerable difficulty, but would be attended by grave risks both to those who disturbed the matter and also to the inhabitants of the town in question.

It would seem, indeed, unnecessary to amplify instances, although the researches of many careful investigators prove beyond all possible doubt that apathy on the part of the authorities is certainly more the rule than the exception.

THE COMMERCIAL USE OF DESTRUCTORS.

While it is beyond dispute that refuse ought to be burnt, it is only natural that those responsible for its disposal should inquire carefully into the commercial aspect of the matter; and at quite an early stage in the comparatively young history of refuse destructors the builders of destructors sought to utilise the heat of combustion of the refuse for some commercial purpose in order to minimise the costs of destruction.

The commercial possibilities of the supply of electrical energy for lighting and other purposes soon attracted the attention of municipal authorities, and in many cases the supply of electric energy became vested in their hands. As these gentlemen also had to deal with the question of the disposal of refuse, it was no doubt quite a natural conclusion for them to come to, that if refuse in being burnt evolved heat, it might conveniently be used for the purpose of generating electrical energy. Naturally, these ideas were fostered by those interested in the building of refuse destructors, and as a consequence many startling claims were made for the calorific value of town refuse and for its steam raising powers. It would be invidious to mention the names of workers in this field. They have been many and various, and, unfortunately, as no standard conditions were adopted for tests of evaporation of water in boilers fired by refuse, the results obtained as to the amount of water evaporated from and at 212° F. have varied between quite astonishing limits.

The following remarks are not designed to convey the opinion that refuse can never have a utiliseable heat value. There are many instances on record where the heat liberated by the burning of refuse is utilised for a variety of purposes which are more or less commercially profitable, and to that extent reduce the cost of disposal. These purposes are many and various, and no doubt the instances to which I refer will be well known to my readers. But the history of refuse destruction is replete with instances of generalisation from individual cases which has caused erroneous impressions to take possession of the minds of local authorities and others as to the extent to which refuse may be relied upon as a fuel in the usually accepted sense of the word. For instance, a measurement is made of the evaporation of water from a refuse-fired boiler, extending over two hours or twenty-four hours, or whatever it may be, the average steam pressure during this period is worked out, the evaporation is reduced to the equivalent amount from and at 212 F., and the refuse in that particular neighbourhood is thereupon labelled as having an evaporative power of so and so many pounds of water per pound. This is misleading, because the non-technical man is naturally led to assume that if one pound of refuse would evaporate a pound of water, then a ton of refuse should be able to evaporate a ton of water, and if he has 100 tons of refuse to dispose of per day, he concludes that he can rely upon evaporating 100 tons of water, which at 30 lbs. per b.h.p. hour should give him roughly 7,000 h.p. hours of mechanical energy to apply to any commercial purpose. He then goes on to work out that one b.h.p. hour is equal to about ten sixteen-candle-power incandescent lamps burning for an hour, so that his 100 tons of refuse should enable him to supply electrical energy for some 3,000 sixteen-candle-power lamps for twenty-four hours. The above argument can, however, never be correct, the reasons for which will become abundantly evident from a consideration of the average composition of refuse in various districts.

COMPOSITION OF REFUSE.

There can be no doubt that the quality of refuse varies considerably in different parts of England, and, indeed, in different parts of the same town; for instance, in residential or manufacturing districts, ash-bin refuse may contain quite a considerable proportion of half-burnt coal or other combustible. On the other hand, in purely agricultural districts, the refuse would probably be of such a character as to contain scarcely enough combustible to burn itself, much less to evaporate water in a boiler. Moreover, the quality of the refuse varies more or less in every locality with the season of the year.

As an example of the kind of material one finds in town refuse, the following quotation from Colonel Codrington's report will be of interest:—

"These records are sufficient to indicate the varied composition of refuse, and when considering the possible value of refuse for raising steam for any purpose requiring a steady pressure, it must be borne in mind that this class of refuse is not the only one that has to be dealt with in a large town. For instance, during one year at Leeds the following 'articles' were dealt with, in addition to the usual ash-bin refuse: 11 cows, 3 calves, 17 sheep, 4 goats, 298 pigs, 5 turkeys, 2 carcases of beef, 28 quarters of beef, 9 cwt. of pork, 10 cwt. of pickled tongues, 12 cwt. of herrings, 218 cwt. of shell fish, 1 cwt. of sugar, 285 dogs, 109 cats, 13 foxes, 1 'sea serpent,' 147 mattresses, bed pillows, and bolsters, 7 blankets, 36 pieces of carpet, 7 hearth rugs."

Colonel Codrington gives the following list as the standard of the average London refuse:—

Ashes	52·6
Breeze (cinders)	28·8
Soft core (animal and vegetable refuse	14·2
Hard core (broken pottery, etc.)	2·9
Coal	0·15
Bones	0·25
Rags	0·425
Old iron	0·35
Old metals	0·025
White glass	0·075
Black glass	0·225
	100·000

And the average composition of Manchester refuse is given as follows:—

Ashes and excreta in pails ...	64·5
Dust and cinders	34·55
Fish and bones	0·15
Dogs, cats, hens, rabbits, etc....	0·05
Boots, rags, hats, paper, etc. ...	0·05
Vegetable refuse	0·05
Glass, pottery, bricks, etc. ...	0·6
Old iron and tinware	0·05
	100·00

As an instance of the composition and variation of town refuse at different seasons of the year the following analysis of Torquay refuse, taken from Mr. Henry A. Garrett's able paper on this subject, which was contributed at the summer meeting of the Institution of Mechanical Engineers two years ago, is interesting and instructive:—

Refuse for December and January tests consisted of—

	Per cent.
Paper, cardboard boxes, straw packing material and the like... ...	12·29
Vegetable and garden refuse impregnated with fine ash	52·07
Screenings, cinders, clinker, pieces of small coal and the like ...	6·51
Fine ash and dust	25·42
Pots, pans, crockery, bottles, etc. ...	3·17
Rags, bones, etc.	0·35

In December and January refuse is usually admitted to be of the best quality from a "fuel" point of view. Mr. Garrett sampled about 8 tons of refuse collected in June with the following result:—

	Cwts.	qrs.	lbs.
Fish offal	3	2	21
Meat and poultry offal ...	0	3	17
Waste bread, cake ...	0	1	15
Brickbats, stones... ...	0	2	3
Bits of wood, old boxes...	0	0	23
Old tins, pans, pails ...	3	2	9
Bits of old iron	1	1	0
Pots	1	2	4
Bottles and glass... ...	1	3	18
Straw	1	1	8
Waste paper	3	2	17
Vegetable refuse... ...	11	3	9
Garden prunings... ...	4	1	0
Bones	0	1	5
Rags	0	0	17
Bits of canvas	1	1	7
Old boots and shoes ...	0	0	11
Fine dust	77	0	0
Screenings	45	2	0
Bits of coal	0	2	17
Bits of coke	0	0	21

A glance at these lists is sufficient to show that, from the point of view of the fuel, town refuse cannot be considered of very high grade. It is, therefore, somewhat difficult to understand how such results as 2 lbs. of water evaporated per pound of refuse burnt could be seriously put forward as an average result that might be relied upon. This difficulty is accentuated if one analyses the distribution of the heat of combustion of refuse.

ITS HEAT POTENTIALITY.

A comparison of the results of refuse burnt in many districts shows that, on the average, refuse may be taken to contain at least 30 per cent. of moisture, and that on the average at least 30 per cent. consists of incombustible material; this leaves 40 per cent. of material which is more or less combustible. This 40 per cent. is the sole source whence heat can be drawn for the purposes of evaporating the inherent moisture, for supplying the heat necessary for raising the temperature of the mass to that of the furnace, for the heat escaping in the issuing gases, and for the heat required for evaporating the aforesaid 2 lbs. of water per pound of refuse from and at 212° F. Assuming that the temperature of the products of combustion is 1500° F., that the specific heat is 0·23 thermal unit, that the air supplied and the products of combustion amount to 3·5 lbs. per pound of refuse, and that the moisture in the refuse carries away with it only 966 thermal units per pound, we find the following number of thermal units to be necessary for the combustion of the refuse and the evaporation of 2 lbs of water:—

Heat lost in waste gases, say 1,500 × 0·23 thermal units (specific heat of gases) × 3·5 lbs.	1,207
Heat lost in clinker, raised to, say, 2,000 deg. in furnace from 60 deg.—1940 × 0·2 × 30 per cent.	116
Heat lost in evaporation of moisture, 30 per cent. of 966 thermal units ...	290
Heat absorbed in 2·0 lbs. water from and at 212° F.	1,932
Thermal Units	3,545

To this should be added radiation losses, say, 150 thermal units, making a total of 3,545 + 150 = 3,695 thermal units.

Now, these 3,695 thermal units can only have been produced by 0·4 of the pound of refuse which is combustible, which, therefore, must have had a calorific value of 9,230 thermal units per pound. This is, of course, absurd.

It may be suggested that the evaporation of water above referred to is no longer seriously claimed by reputable makers of destructor furnaces, and this is certainly true; at the same time, within the last few months, Mr. Frank Broadbent, in an excellent article which ran through several numbers of the *Electrical Review*, gave a table of the results claimed by many authorities for the evaporation achieved by their destructors, and the figures therein quoted show variations within fairly wide limits. This paper is a most interesting and instructive one, and, of course, Mr. Broadbent is not responsible for the figures nor for the means by which they were obtained, and it is, moreover, impossible to criticise these results upon anything except general lines, for the reason set forth at the commencement of this article, namely, that up to the present no standard conditions for boilers fired by the combustion of refuse have been agreed upon by the various authorities dealing with this subject.

Mr. Dawson gives the calorific value of the combustible constituents of refuse as follows:—

	Thermal Units per lb.
Coal	9,344
Coke	8,000
Bones and offal...	5,344
Breeze and cinder	4,000
Rags	3,334
Paper, straw, and the like ...	2,534

From these data Mr. Broadbent compiles a table in which the calorific value of each constituent of average quality London ashbin refuse is calculated. He brings the total to 1,428 thermal units per lb., or about one-tenth that of good coal; but it must not be forgotten that on the average only 40 per cent. of refuse by weight consists of combustible, so that the material which can produce 1,428 thermal units is unavoidedly accompanied by one-and-a-half times its weight of incombustible on the average.

Working on similar lines, Mr. Broadbent makes the calorific value of Manchester refuse 3,100 thermal units per lb., and for Torquay refuse (winter) 1,480 thermal units per lb.

Now, taking 30 per cent. clinker and 30 per cent. moisture as fair average conditions for a basis of comparison, we find that (see above) 1,613 thermal units are accounted for in the waste gases, in heating up the incombustible, and in evaporating the moisture in the refuse. In the case of Torquay (winter refuse), therefore, there is no heat available for evaporating water if Mr. Broadbent's calculations and my assumptions are correct. In the case of Manchester refuse, 3,100 - 1613, or 1487 thermal units, would be available for steam raising, being equivalent to $\frac{1,487}{966} = 1{\cdot}54$ lbs. water from and at 212°F, and in the case of ordinary London ash-bin refuse, again, there would not appear to be sufficient heat value to consume the refuse itself.

EXPECTATIONS AND MISCONCEPTIONS.

The evaporative power of refuse must of necessity be a fluctuating quantity and wholly unreliable, and all the improvements in destructors or in refuse fired boilers will not alter matters in this direction in the least. If every effort is directed towards turning the refuse destructor into an auxiliary steam producer for the town's electricity works, then the efficiency of the destructor *quâ* destructor will be impaired, and, conversely, if a destructor is worked with a view to the attainment of the highest degree of efficiency in its legitimate sphere, a boiler fired by the products of combustion of the refuse will be wholly unreliable for the purposes of supplying steam under conditions such as obtain in an electric generating station. If the heat utilised is arranged not to greatly exceed the minimum heat output of the furnace in use at any one time, there will obviously be no difficulty in utilising this portion of the heat of combustion for purposes requiring a constant boiler pressure, proper arrangements being of course made for the utilisation or disposal of the surplus steam, so that the boiler pressure will not be thereby unduly raised, and in these circumstances the utilisation of steam from a refuse fired boiler need not interfere with the functions of the destructor as a sanitary appliance. But it will never be possible for the engineer to rely upon refuse as a fuel for steam raising, in the way that many recent writers would have us believe.

The advocates of refuse as a fuel seem to overlook the important difference between refuse and coal or any other "fuel." Whereas the chief characteristic of a fuel is the constancy of its component parts, the very opposite holds good in the case of refuse; and whereas, therefore practically every pound of coal in a ton may be reckoned on to contribute the same proportion of heat when consumed in the furnace, in the case of refuse as fed into a destructor it would be impossible to rely upon two consecutive pounds to produce even an approximately equal amount of heat.

The conditions under which so-called determinations of the thermal value of refuse as a fuel have been made are really quite hopeless. Refuse is fed into the destructor furnace—I had almost said—by the cartload as against the shovelful in the case of coal, and yet the evaporation of a refuse fired boiler is often worked out to two places of decimals after a trial of a few hours' duration. No wonder people are led to take an exaggerated view of the possibilities of refuse!

If it should be desirable to obtain some approximately correct idea of the average heat value of the refuse collected in some particular town or district—though what useful purpose can thereby be served it is difficult to imagine—careful measurements of the amount of refuse destroyed and of the water evaporated should be taken over at least one year, and then it is quite possible that similar measurements taken during the following year would show a different result. If, in addition to these measurements, the boiler pressure be noted where the whole available heat is used to evaporate water, the variations in pressure would be such as to disabuse the mind of any steam user of any false ideas on the subject.

The proof of the pudding is the eating of it, says an old proverb, and there is no instance on record of steam for electric lighting or power purposes being continuously and satisfactorily drawn from a refuse fired boiler to the extent indicated by the number of pounds of refuse burnt multiplied by the alleged evaporative power per pound of refuse.

To again quote from Mr. Broadbent's excellent paper, we find in Table V. a column giving the useful Board of Trade units generated per ton of refuse. Rejecting results obtained from observations extending over less than one month, and from plants where coal is mixed with the refuse, the average works out to nearly 32 kilowatt hours per ton of refuse burnt. These results are obtained at Accrington, Shipley, and Wrexham.

Taking 40 pounds of steam per kilowatt hour as a not too extravagant estimate, 32 kw. per ton of refuse would correspond to 32 × 40 = 1,280 pounds of water evaporated per ton of refuse, or a little over half a pound of water per pound of refuse. This is accounted for by the nature of the districts in which the results were obtained, and of course cannot be taken as representative of the steam-raising power of every kind of refuse.

The foregoing remarks are not designed to convey the view that the heat value of refuse should be entirely discounted. Heat is always heat, however produced, and it is well known that in many towns the steam from refuse fired boilers is utilised for a variety of purposes which admit of intermittent working. In several instances the steam, when available, is used for generating electrical energy for charging secondary batteries. In other cases other means of equalising the supply of and demand for steam have been attempted, *e.g.*, M. Druitt Halpin's Thermal Storage Scheme. In these or similar ways the heat energy of refuse can be turned to some commercial purpose, and thus effect a reduction in the cost of burning. But upon this subject no rules can be laid down—only an intimate knowledge of the requirements of the districts and of the facilities at hand for the disposal of the article produced can dictate how best to utilise the heat from the refuse destructor.

The paramount *duty* of a refuse destructor is to completely consume the refuse within the least possible time from the moment it is delivered by the cart, and to effect its destruction in such a way that no stewing of the refuse prior to its discharge into the furnace takes place, and that the temperature of the combustion chamber is maintained at a sufficiently high point to thoroughly cremate and render innocuous the products of combustion. Further, the design of the flues and of the chimney should be such that all dust is deposited, and that no solid matter finds its way up the chimney to be discharged at its mouth.

In designing a destructor furnace to effect these three important functions, neither trouble nor money should be spared. A refuse destructor must be looked upon as a necessary sanitary appliance, and not as a money-earning machine.

A STATISTICAL REVIEW OF BRITISH COAL AND IRON PRODUCTION.

A STRIKING fact connected with the production of coal and pig-iron is that, while America has outpaced all her records, she has this year been buying both from us. It is also a striking fact that the output of coal in the United Kingdom has declined, although more persons have been employed in mining. In 1901 the decline was 6,134,355 tons on 1900, and the proportions of the decrease were 3·68 per cent. in England, 0·95 per cent. in Scotland, and 0·21 per cent. in Wales. There were 839,178 persons employed in the mines, as against 814,517 in 1900; but the output was only 357 tons per person employed underground, as compared with 382 tons in 1900.

THE EFFECT OF HIGH WAGES.

This serious decrease in productive industry of 25 tons per man is attributable to shorter hours and fewer working days. When wages are high, miners can, and do, take frequent holidays. In any case, the average annual production of the British miner compares badly with that of the American, which is about 550 tons per man. The difference is a very serious one, and is, we believe, due more to the longer working week and fewer holidays in America than to the use of coal-cutting machinery in the mines there, although that is, no doubt, an important item. As to the smaller number of hours worked in the British pits during 1901, it is but fair to add that this was to some extent the result of taking on again reservists and militia men returning from active service. They were put on the books, but as trade was declining, many of the pits were over supplied with labour, and had to choose between running short days and paying off men.

THE USE OF COAL-CUTTING MACHINERY.

As to the use of machinery, it may be noted here that American records show that ten years ago each man in the bituminous mines turned out 2·56 tons per day, and now produces 2·98 tons. This is called an increase of 118 tons per annum per miner. In the anthracite mines the daily production in the same time has increased from 1·85 tons to 2·4 tons. This is claimed as being due to the application of improved mechanical appliances; but there were doubtless some other influences at work as well. There was, everywhere, considerably less demand for coal in 1901 than in 1900, except in America, where an increase of 20,000,000 tons in the output was readily absorbed. Our exports fell off by 2¼ million tons, and the consumption in the British blast furnaces was 2½ million tons less than in the previous year, although the price for the year averaged 1s. 5d. per ton lower.

THE PRODUCTION OF ANTHRACITE COAL.

As a good deal of surprise was caused in September and October last by the receipt of orders from the United States for cargoes of anthracite coal to be shipped from Wales and Scotland, it may be explained that this quality of coal is regularly raised in both countries. The Welsh anthracite more nearly resembles American in character than does the

Scotch, which latter is a hard and smokeless coal, mostly used in the furnaces of steam yachts and the like. There is also a small quantity of anthracite produced in Ireland. The following shows the

OUTPUT OF ANTHRACITE IN THE UNITED KINGDOM.

	Tons.
Wales—	
Brecon	393,677
Carmarthen	894,555
Glamorgan	923,644
Pembroke	42,190
Scotland	224,780
Ireland	86,616
Total in 1901	2,565,462
„ 1900	2,523,150

These figures, shown here separately for their special interest, are included in the official returns of the entire output of coal in the country, and the output in 1901 was :—

TOTAL OUTPUT IN 1901.*

	Tons.	Increase or decrease on previous year.
England ...	153,460,284	—5,865,118
Wales ...	32,686,832	+ 67,837
Scotland ...	32,796,800	— 315,404
Ireland ...	103,029	— 21,670
Total, 1901	219,046,945	—6,134,355
„ 1900	225,181,300	+5,086,519

Here, then, we find a decrease of 6,134,355 tons, as compared with a previous increase of 5,086,519, say a practical falling off of about 11 million tons. It must cause some surprise to find Scotland recorded as a larger coal producer than Wales, but in the above table the output of the Monmouthshire pits is credited to England, not to the Principality. The output for Wales per county was :—

WELSH OUTPUT, 1901 (MINES).

County.	Tons.
Brecon	442,194
Carmarthen	1,417,427
Denbigh	2,398,776
Flint	677,203
Glamorgan	27,708,841
Pembroke	42,190
Total ...	32,686,631

But if we add the Monmouthshire production, the output of the Welsh coalfields would be over 42 million tons. The following is the—

ENGLISH OUTPUT, 1901 (MINES).

County.	Tons.
Cheshire	570,216
Cumberland	2,108,360
Derby	14,907,344
Durham	33,954,438
Gloucester...	1,524,981
Lancashire	23,690,503
Leicester	2,011,350
Monmouthshire	9,598,407
Northumberland	11,272,005
Nottingham	8,198,267
Salop	754,858
Somersetshire	928,539
Staffordshire	13,122,272
Warwick	3,099,863
Westmorland	898
Worcester...	735,800
Yorkshire	26,972,969
Total ...	153,451,070

It will be seen that the output of Durham alone exceeds both that of all Wales and all Scotland. The following is the

SCOTCH OUTPUT, 1901.

County.	Tons.
Argyllshire and Dumfries ...	127,939
Ayrshire	4,046,278
Clackmannan	429,836
Dumbarton	501,139
Edinburgh	1,364,399
Fife	5,601,501
Haddington	467,225
Kinross	22,528
Lanark	16,603,230
Linlithgow...	1,316,570
Peebles	900
Renfrew	2,346
Stirling	2,306,880
Sutherland...	5,739
Total ...	32,796,510

More than half the output of Scotland is from one county, Lanarkshire. But the output of Durham and Northumberland is far away ahead of all the coalfields. The number of men employed, the average output per underground worker, and the average price at the pit's mouth are as follows :—

	No. of men employed.	Output per miner. Tons.	Average price. s.	d.
Durham	113,934	393	8	6¾
Northumberland ...	41,145	345	9	10
All England ...	561,363	352	9	1½
Wales	128,783	303	11	11¼
Scotland	101,569	405	7	10½
All United Kingdom	792,648	350	9	4¼

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* These figures include the small quantities produced from open quarries (9,705 tons in 1901 and 11,137 tons in 1900) omitted from subsequent tables.

WHERE THE COAL GOES.

The next thing to consider is what has become of all the coal, and the answer, unfortunately, is that the greater portion of it was wasted, in so far as effective power is concerned. About one-tenth of our output goes into domestic use, but not more than 1 per cent. of that proportion is consumed beneficially. Of what is consumed industrially, probably not more than ten per cent. of the theoretical power is actually obtained. But as to distribution, it has been as follows during the last ten years :—

Year.		Output. Tons.	Exported. Tons.	Consumed at home.	Consumption per head. Tons.
1892	...	181,786,871	39,380,756	142,406,115	3·737
1893	...	164,325,795	37,488,070	126,837,725	3·300
1894	...	188,277,525	42,687,430	145,590,095	3·755
1895	...	189,661,362	42,907,302	146,754,060	3·752
1896	...	195,361,260	44,586,811	150,774,449	3·820
1897	...	202,129,931	48,128,464	154,001,467	3·867
1898	...	202,054,516	48,266,699	153,787,817	3·826
1899	...	220,094,781	55,810,024	164,284,757	4·051
1900	...	225,181,300	58,405,087	166,776,213	4·075
1901	...	219,046,945	57,783,076	161,263,869	3·882

In the exports we have included the quantities supplied to the bunkers of steamers engaged in the foreign trade; as also coke in the proportion of 100 tons of coal for every 60 tons of coke shipped, and patent fuel in the proportion of 90 per cent. of coal in every ton of fuel shipped. The amount of bunker coal supplied to British and foreign steamers in the foreign trade in the ten years has been :—

BUNKER COAL SHIPPED.

Year.		Tons.
1892	... ...	8,600,129
1893	... ...	8,126,372
1894	... ...	9,294,461
1895	... ...	9,407,780
1896	... ...	9,937,305
1897	... ...	10,455,758
1898	... ...	11,264,204
1899	... ...	12,226,801
1900	... ...	11,752,316
1901	... ...	13,586,833

As regards the decrease in the consumption last year it was explained partly by the long continuance of hot weather, but mainly by the reduced activity in the iron industries. The average price at the pit head and in London has thus varied during the ten years :—

AVERAGE PRICE AT PIT HEAD AND IN LONDON.

Year.		England.		Wales.		Scotland.		In London Market.	
		s.	d.	s.	d.	s.	d.	s.	d.
1892	...	7	3	8	10	5	9	17	7
1893	...	6	10	7	8	5	9	19	0
1894	...	6	7	7	6	6	0	16	4
1895	...	5	11	7	2	5	4	14	7
1896	...	5	10	6	9	5	1	14	5
1897	...	5	11	6	7	5	3	15	4
1898	...	6	4	6	10	6	1	16	2
1899	...	7	7	7	9	7	6	18	2
1900	...	10	6	12	0	10	10	22	0
1901	...	9	1	11	11	7	11	19	5

It will be seen that not by any means the whole of the great haul of the "famine" year, 1900, was lost last year.

The distribution of the output by water last year was lower in comparison with 1900 :—

SHIPPED BY WATER.

	1900. Tons	1901. Tons.
Coastwise—		
Coal	17,923,884	17,895,546
Coke	71,180	66,859
Patent Fuel ...	1,874	305
	17,996,938	17,962,710
Foreign and Colonial—		
Coal	44,089,197	41,877,081
Coke	985,365	807,671
Patent Fuel ...	1,023,666	1,081,160
	46,098,228	43,765,912
To the bunkers of steamers in the foreign trade ...	11,752,316	13,586,833

The largest consumption of coal is in the iron industry; but before we go on to that it will be of interest to show the consumption for locomotive purposes on the various railways. The records only go back to 1897 :—

RAILWAY CONSUMPTION OF COAL.

Year.	England and Wales. Tons.	Scotland. Tons.	Ireland. Tons.	United Kingdom Tons.
1897	7,420,659	1,573,682	272,913	9,276,254
1898	7,089,942	1,670,563	311,308	9,971,813
1899	8,604,289	1,763,154	298,698	10,666,141
1900	9,090,118	1,779,608	327,396	11,197,122
1901	8,021,178	1,754,680	347,035	11,022,893

IRON ORE.

Turning to iron ore we find a decrease both in the output and in the imports, sufficiently indicative of a decline in the iron trade. The chief producing districts are Cleveland and North Yorkshire, Lincolnshire, Northamptonshire, and Leicestershire, Cumberland, and North Lancashire, Scotland and Ireland. The richest ore is the hematite produced by the Cumberland and Lancashire mines, which averages over 50 per cent. of metal per ton of ore; the Cleveland ore averages about 30 per cent.; and the Midland ores average about 33 per cent. The following is a statement of the

OUTPUT OF IRON ORE IN GREAT BRITAIN FOR THE YEAR 1901.

District.	Output. Tons.	Decrease on previous year. Tons.	Percentage of total.
Scotland	759,373	89,658	6·2
Cumberland & Lanc.	1,559,447	174,344	12·7
Cleveland	5,100,823	392,910	41·6
Stafford	825,965	258,832	6·7
Lincoln	1,494.474	430,424	18·2
Northampton ...	1,485,084	137,455	12·1
Other counties ...	969,500	250,278	7·9
Ireland	80,532	19,109	0·6
Totals ...	12,275,198	1,753,010	100·0

The decrease in 1901 is equal to 12½ per cent. on the output of 1900. From this quantity of home ore 4,091,908 tons of pig-iron were smelted in 1901, as compared with 4,666,942 tons in 1900. To come down to counties, the following was the

ENGLISH OUTPUT OF IRON ORE.

County.	Tons.
Cumberland	1,009,911
Derby	2,536
Devon	225
Durham	19,503
Gloucester	9,769
Lancashire	549,536
Leicester	593,908
Lincoln	1,494,474
Monmouth	10,733
Northampton	1,485,084
Oxford and Rutland	230,011
Salop	25,586
Somerset	411
Stafford	825,965
Warwick	7,267
Wiltshire	7,076
Worcester	4,882
Yorkshire (Cleveland, etc.) ...	5,150,656
Total ...	11,427.533

Wales and Ireland are both too trifling to enumerate, but the following was the—

SCOTCH OUTPUT OF IRON ORE.

County.	Tons.
Ayrshire	306,436
Dumbarton	53,246
Edinburgh	29,006
Fifeshire	31,737
Lanarkshire	153,308
Linlithgow	53,915
Renfrew	125,553
Stirling	6,172
Total ...	759,373

To make up for the smallness of our deposits of hematite ore we have to import ore for steel-making iron. It remains to be seen how the new process of obtaining steel-making iron from ordinary ore will stimulate the output of ore in Cleveland. But last year even our imports of foreign ore declined, although in 1900 so much effort was exerted to beat up new sources of supply. In the following table we show the quantities received from our several suppliers in 1900 and 1901:—

IMPORTS OF IRON ORE.

From	1900. Tons.	1901. Tons.
Algeria	141,624	189,014
Australia	5,313	6,375
Canada	4	3,124
France	48,165	44,930
Greece	304,648	303,835
Holland	9,414	13,670
Italy (Elba)	88,532	70,362
Newfoundland ...	13,234	35,576
New Zealand	28	—
Portugal	11,738	20,040
Spain	5,551,559	4,749,933
Sweden	98,055	87,575
Turkey	8,061	7,627
Other countries ...	17,588	16,827
Total ...	6,297,963	5,548,888

It is still a case of Spain first and the rest nowhere, even though the readily available supplies of the best Spanish ore are nearing exhaustion; but great things are expected of Sweden in the near future. And we have always Newfoundland and Nova Scotia to resort to for ore for basic iron, for the production of which, on a large scale, our smelters will have to adapt their furnaces.

THE BRITISH OUTPUT.

This brings us to the consideration of our own output of pig-iron in respect of the supplies of coal and ore revealed. Of the quantity of native ore produced, 3,955 tons were exported; and, of the quantity of foreign ore imported, 8,127 tons were exported. The amount available for home use was reduced by the sum of these quantities, but a further quantity of material was available for the furnaces in the shape of purple ore from the cupreous pyrites imported. From these materials we work up the actual quantity of iron-making material last year as follows :—

IRON ORE AVAILABLE IN UNITED KINGDOM, 1901

	Tons.
Quantity of ore produced at home	12,275,198
Quantity imported	5,548,888
Purple ore, from cupreous pyrites	490,198
Total	18,314,274
Deduct—British and foreign ore exported ...	12,082
Net quantity available for consumption, apart from mill and forge cinders	18,302,192

(This quantity compares with 20,882,244 tons in 1900.)

In addition, there were 962,784 tons of cinders, etc., used in some of the furnaces, so that the total quantity of smelting material available was 19,264,276 tons. In smelting this, 16,273,527 tons of coal were consumed, and the product was 7,928,647 tons of pig-iron. In 1900 8,959,691 tons of pig-iron were smelted from 22,100,774 tons of material with 18,742,022 tons of coal. The following shows the distribution of make :—

	Furnaces built.	Furnaces at work.	Pig-iron made. Tons.
England	443	$238\frac{2}{12}$	6,297,868
Wales	43	$15\frac{1}{12}$	494,383
Scotland	101	$82\frac{11}{12}$	1,136,396
Total, 1901 ...	587	$336\frac{1}{12}$	7,928,647
„ 1900 ...	604	$403\frac{3}{12}$	8,959,691

Now we will analyse the English output by districts and qualities thus :—

OUTPUT OF PIG-IRON IN ENGLAND, 1901.

County.	Hematite.	Ordinary and Basic.	Spiegeleisen, Ferro-Manganese, etc.	Total.
	Tons.	Tons.	Tons.	Tons.
Cumberland ...	748,451	2,423	39,215	790,089
Derby and Notts	—	457,519	—	457,519
Durham ..	436,986	499,766	24,281	961,033
Lancaster ...	524,806	49,659	68,028	642,493
Leicester and Lincoln ...	—	321,969	—	321,969
Monmouth and Flint... ..	134,280	34,555	36,834	205,669
Northampton ...	36,000	170,101	—	206,101
Salop	—	40,660	—	40,660
North Stafford	—	225,388	—	225,388
South Stafford	—	283,773	—	283,773
Wilts and Worcester	—	57,086	—	57,086
York, North ...	579,923	1,222,924	56,236	1,859,083
„ N.W. ...	—	247,005	—	247,005
Total ...	2,460,446	3,612,828	224,504	6,297,868

The Welsh production was all in Glamorganshire and Denbighshire, and consisted of 468,405 tons of hæmatite and 25,978 tons of ordinary and basic, in all 494,383 tons. The following was the

OUTPUT OF PIG-IRON IN SCOTLAND, 1901.

County.	Hematite.	Ordinary and Basic.	Spiegeleisen, etc.	Total.
	Tons.	Tons.	Tons.	Tons.
Ayrshire ...	140,303	184,657	—	324,960
Lanarkshire and Stirling ...	445,666	358,090	7,680	811,436
Total	585,969	542,747	7,680	1,136,396

Taking the same ten years with which we have dealt above, we now summarise the pig-iron industry thus :—

SUMMARY VIEW OF BRITISH PIG-IRON INDUSTRY.

Year.		Furnaces in blast.	Pig-iron made. Tons.	Ore smelted. Tons.	Coal used. Tons.
1892	...	362	6,709,255	16,344,454	13,860,201
1893	...	327	6,976,990	16,620,653	13,806,728
1894	...	325	7,427,242	17,803,998	14,884,800
1895	...	344	7,703,459	18,629,337	15,224,517
1896	...	373	8,659,681	21,204,284	17,114,374
1897	...	380	8,796,465	21,327,013	17,552,430
1898	...	378	8,609,719	20,958,167	17,196,439
1899	...	411	9,421,435	22,820,302	19,061,318
1900	...	403	8,959,691	22,100,774	18,742,022
1901	...	336	7,928,647	19,264,976	16,273,527

Thus 1899 was the record year everywhere. An idea of how production has been facilitated by enlargement of furnaces, etc., may be gathered from the fact that in 1873 it took 683 furnaces to produce 6,566,451 tons of pig-iron from 16,820,035 tons of ore with 16,718,532 tons of coal. It takes between 2 and 2½ tons of coal to smelt every ton of pig-iron now produced, and the tendency seems to be to increase in fuel consumption as lower grades of ore are used.

To conclude this statistical review we now show the total quantity of pig-iron available for consumption here last year, in addition, of course, to the stocks :—

SUMMARY POSITION OF PIG-IRON, 1901.

	Tons
Produced from British and foreign ore ...	7,928,647
Exported	830,182
Total British make	7,098,465
Plus American and other pig-iron imported ...	186,409
Total pig-iron for British consumption ..	7,284,874

This is less than half the output of pig-iron in the United States last year, nearly all of which was consumed in America.

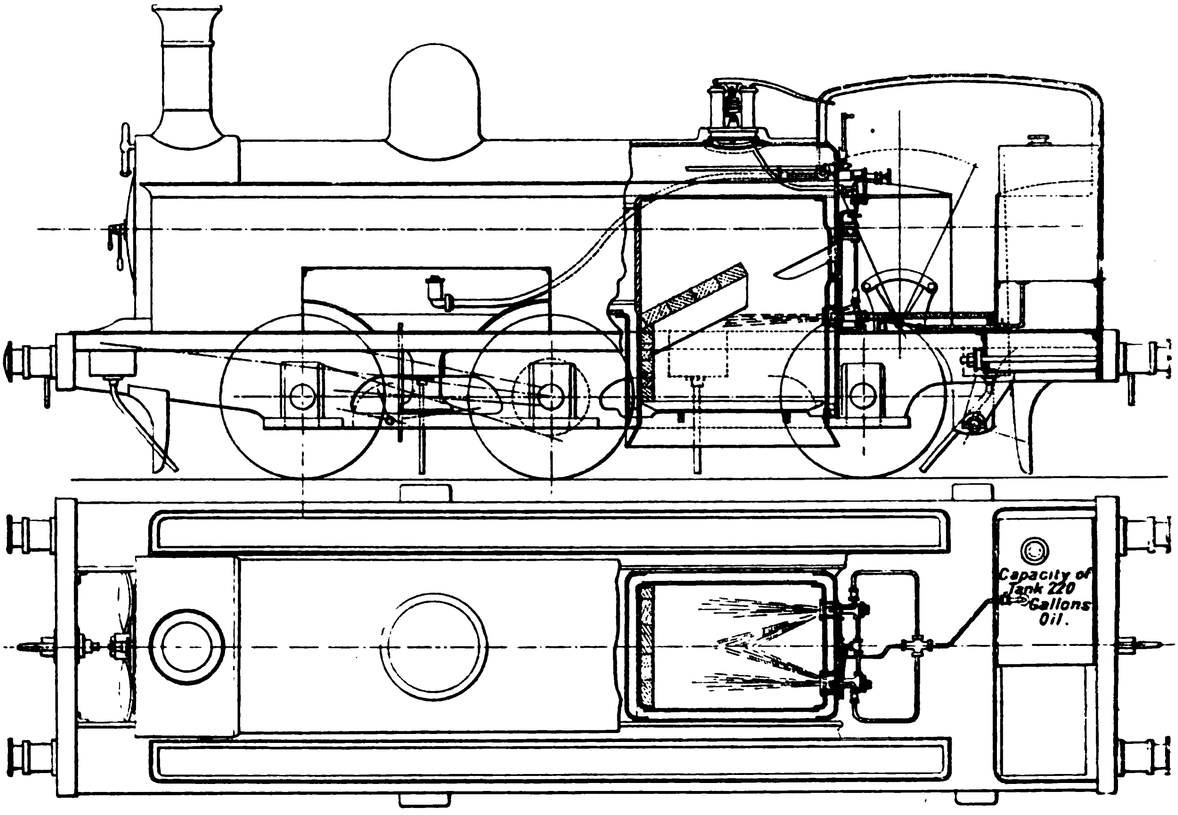
LOCOMOTIVE ENGINEERING NOTES.

Liquid-fuel for Locomotives.

In a previous number of this Magazine reference was made to the important extension in progress and in contemplation of the use of liquid-fuel in locomotives. There seems to be little doubt that this will prove a prominent factor in the future of railway economics. To what extent its influence will prove operative must of necessity depend largely upon the feasibleness of cheapening the present cost of delivery of the fuel. The entrance of fresh and cheaper sources of supply in the case of the Texas mineral oils has made possible the extended use of this fuel. It must be remembered that when Mr. James Holden, the very able and progressive chief mechanical engineer of the Great Eastern Railway, devised his admirable combination system for that line, his primary object was the destruction of troublesome refuse. The tar resulting from the production both of coal gas and oil gas at the Company's works had to be got rid of. It had been discharged into the nearest stream until the local authorities raised objections to the powerful odour, refusing to be mollified by the prismatic colouration of the surface. The only alternative course appeared to be its consumption in a destructor, but an experiment with a stationary engine proved its capabilities as a fuel used in the generation of steam. But this refuse tar could not profitably be burned in engines fitted up like the Russian and American oil-burning locomotives for the consumption of low-flash-point mineral oils. It had to be used in combination with solid fuel, and this necessity proved the mother of Mr. Holden's ingenious invention.

Liquid-fuel Supplies and Carriage.

But the outcome has been that instead of having engines of special construction which can only be used with their particular brand of liquid-fuel, we have a class that can work equally well with coal, and which, in the almost impossible event of a total stoppage of liquid-fuel supplies, can be run just as well with solid fuel like the Company's other engines: the particular apparatus fitted for the use of liquid-fuel in conjunction with solid would offer no obstacle to the exclusive use of coal. It is this special feature of the Holden method which has brought it into such large use on the railway which was the scene of its original adoption, and which is now opening out such large prospects of extension. For some years past it has been evident that, given the necessary supplies of liquid-fuel at a practicable cost, the system must spread far and wide. Even if liquid-fuel cost somewhat more than coal, there would be large advantages in its employment owing to its possessing the merits of simplicity, cleanliness and saving of wear and tear. It has been tried experimentally on several English railways, and is understood to have been virtually adopted by several of their number. It is no secret that in more than one case it would have been in use long ago had there been any reasonable prospect that the needful fuel could be obtained at a practical cost. But the chief mechanical engineer of one line, who was very anxious to adopt it, on making preliminary inquiries, found that all the available supplies in his neighbourhood had already been secured in advance by the Great Eastern. It has been the cheapening and extension of the fuel supplies by the Texas oils coming upon the market which has made it possible for other lines to bring the system into use; and present appearances point to considerable further cheapening when the methods of shipment and over-sea conveyance shall be brought more thoroughly up-to-date than at present. So far, the provisions for shipment are of a somewhat primitive character—a rather surprising fact when one remembers that the locality is America; also the steamers used for the trans-oceanic carriage are relatively small and by no means up to modern requirements. Far larger vessels are, however, in course of construction, and it may reasonably be anticipated that a comparatively short period will witness very material saving in the cost of production and conveyance, bringing about proportional cheapening in the cost of the oil on delivery. But even in existing circumstances the system is understood to have been adopted, not only by the North-Eastern, the London, Brighton and South Coast, and the South-Eastern and Chatham Railways of England, but also by the Paris, Lyons and Mediterranean and other Continental lines.



By the courtesy of Mr. W. F. Pettigrew.

LIQUID FUEL LOCOMOTIVE USED ON THE FURNESS RAILWAY.

This Tank Engine, fitted for burning liquid fuel, was built in 1867 by Messrs Sharp, Stewart and Co. for the Furness Railway, and is used chiefly to assist in banking goods and mineral trains between Plumpton and Lindal, a distance of about 3¾ miles, with a gradient at some points of 1 in 76; also between Askam and Lindal, a distance of 5½ miles, and gradients in 1 in 63. The cylinders are 18 in. diameter, with a 24-in. piston stroke. The coupled wheels are 4 ft. 7½ in. in diameter. The boiler is 4 ft. 2 in. in diameter, and its barrel is 10 ft. 6 in. long. The length of the firebox casing is 5 ft. 6 in., giving a grate area of 15·6 square feet, the tube-heating surface being 1,016 square feet, and that of the firebox 95 square feet, making a total of 1,111 square feet. The working pressure is 140 lbs. per square inch. The water tanks have a capacity of 1,000 gallons, and the liquid fuel tank of 220 gallons. The total weight of the engine in working order is 44 tons 14 cwt.

Probable effect on Railway Economics.

It is manifest that if these expectations be realised, the effect must be tantamount to something very like a revolution in railway economics. For one thing, as has been already remarked, there will be less wear and tear, owing to the superior cleanliness and freedom from dust, and to the diminished labour placed upon the firemen—also, perhaps, through the simplifying of the duties of both driver and fireman, which may avert a good deal of the distraction of attention from signals, etc., which is almost inseparable from the onerous character of their present duties. But beyond this, it will in a material measure eliminate from railway finance the disturbing element of coal prices. A large quantity of coal would of course still be required, even if Mr. Holden's system came into universal adoption. But the quantity required would steadily decrease, and in view alike of the gradual exhaustion of our British coal supplies and the prevalent tendency to increase in price, this cannot fail to prove a matter of substantial importance.

The Clamour for Electric Traction.

One hears so much nowadays of the possibilities and probabilities of electric traction, that it is curious to reflect how very little is really known on this subject. "Electrification of our railways" is spoken of with a cheerful and free-and-easy confidence as if every difficulty in the way of this change had been completely grappled with and thoroughly overcome. Yet it would be much more accurate to say that electric traction, as applied to railways, is still in its very tender infancy. That it can be and has been applied with much success—and a few mishaps—to urban and suburban railway working, albeit to a strictly limited extent, is of course quite true. That its use in these phases of railway work will rapidly and steadily increase is also virtually certain. But even allowing the widest scope of possibility on the basis at present existing, it must be candidly admitted by all who are thoroughly conversant with the necessities of the case and the obstacles to be overcome, that a very great deal more has still to be achieved before any sane management could prudently recommend the complete electrification of a great railway system. Not many months ago the question was directly raised as to whether the terrible overcrowding and perpetual blockade of one of London's most important suburban railways might not be remedied by the adoption of electricity as the motive power. The matter was most carefully considered by the engineering department, which was inclined to be favourable to the change if proved feasible. But the lowest estimate of the cost involved the expenditure of at least a million and a half sterling, which could by no possibility earn any extra revenue. With this huge financial obstacle on the threshold of conversion, even in the case of the mere suburban section of a leading line, it is manifest that were the field of operations to be one of the vast main line systems, such as that of the Great Western, London and North-Western, or Midland, the financial probability would become one of gigantic dimension; thus, before even the idea could be seriously entertained, the ruling powers of a great railway would need to be conclusively convinced that the system would be not only in all respects feasible and convenient, but also would be a very distinct improvement upon steam locomotion. Otherwise its adoption would be in the highest degree imprudent, if not suicidal. That the working of main lines by electric traction may become practicable in the course of time is probable enough, but as matters now stand, it would certainly be unwise for railway companies to waste valuable time and money in extensive experiments with a new and relatively untried system, instead of devoting their attention rather to the improvement of present methods, especially in the direction of getting as much as possible out of steam traction.

British Neglect of Compounding.

Keeping this manifestly important aim in view, most railways, alike in Britain and on the European and American continents, are making strenuous endeavours to increase the available power of their steam locomotives. But the possibilities under this head are unavoidably restricted by the dimensional limitations which rail-gauge and load-gauge impose upon designers. It is therefore manifestly desirable to utilise to the utmost extent possible the limited dimensions that are available. This is where the advantage of compounding comes in. It does not enable a larger boiler to be employed, but it does enable the steam supplied by a boiler of given size to be used to far greater advantage, because it is used twice over. When Mr. F. W. Webb tried a four-cylinder single-expansion high-pressure locomotive on the London and North-Western, he found that his standard boiler could not keep four 15 in. cylinders supplied with "live" steam. But a sister engine, identical in all respects, save in being a compound, obtained ample steam from the same boiler for her two 15-in. high-pressure cylinders, and used it over again with marked advantage in her two 20½-in. low-pressure cylinders. Consequently she proved a success and was multiplied sixtyfold, while the other was converted into a compound also, and, as converted, has done excellent work. On every main line in France, compound engines have long been working with complete success, so too in many other countries. Yet British engineers of the present day have hitherto proved strangely shy of adopting the compound plan, with the exception of Mr. Webb, who has built nearly three hundred compound locomotives for the London and North-Western, and very recently Mr. S. W. Johnson, who is trying two on the Midland line.

Sporadic Experimentalisation.

It is not easy to understand this British reluctance to employ a method which has proved so successful elsewhere. One reason perhaps may be found in that prevalent but quite mistaken idea that some discredit attaches to a chief mechanical engineer, who adopts a system invented by someone else, instead of inventing a brand-new one of his own. He may fear that he will seem lacking in originality and initiative if he advocate the adoption of another man's method and perhaps the payment of royalties for its use. It is difficult to explain otherwise the fact that so many British locomotive superintendents have made casual and sporadic experiments with compounding, yet have in so very few cases produced a successful result. For it is manifest that the practicable variations of design cannot be infinite in number. Thus if one thoroughly successful method be devised, and it be deemed *sine quâ non* that new engines to be built must employ a different method, the balance of probability against such variations proving of superior or even of equal effectiveness, must needs be heavy. It may be that repugnance to accept the initiative of a brother locomotive superintendent in the same country is natural enough, as that might be thought to invite disparaging comparison. But there are other systems of compounding beside that of Mr. Webb, which tested by results, have proved distinctly valuable, such as that of M. de Glehn, which for several years past has been doing such remarkable work within thirty miles of the British coast. Every French main line uses engines constructed on this principle. On most of the leading lines in France all new express locomotives are of this type. That it is more costly in construction is indisputable, but it constantly performs, as a matter of every-day course, work which is deemed sufficient to require *two* engines on several leading British railways, and no fewer than 1,500 of these engines are now at work in Europe. Is it not "passing strange" that none have yet been seen in Britain, where the lines are so seriously overcrowded, where the engines are so often overloaded, and where the demand for increased locomotive power and swifter clearance of the lines is so urgent and incessant and increasing?

Automatic Couplings and British Obtuseness.

A most extraordinary report upon automatic couplings, as used on American railways, was recently made to the London and North-Western Railway by one of its officials who had been visiting the United States for the purpose of special inspection and comparison of railway methods. He says: "Persons who argue in favour of automatic couplings in connection with the safety of the employés, appear to have overlooked the fact altogether that the shunters still have to get between the carriages and waggons in order to make connections between the vacuum pipes and any other fittings that are required throughout the train, and this is a much more difficult job with the automatic couplings than it is with the ordinary screw couplings in use on the British railways. It is perhaps only fair to state that the figures for 1901, which have recently come to hand, show considerable reduction in the number of employés killed and injured in coupling and uncoupling"—these figures of course being those of American railways.

A Curious Perversion.

"A considerable reduction!" Yes, very considerable indeed! For that reduction amounts to 63 per cent. in the number of persons killed and of 80 per cent. in the number of injured, and this tremendous saving of life and limb is, admittedly, mainly due to the adoption of automatic couplings. It is not surprising that the introduction of this most urgently needed improvement should be delayed in Britain when a prominent official of its leading railway regards an avoidance of more than half the fatal accidents as merely a "considerable" reduction in the casualty lists. Nor is this the only strange perversion implied in this peculiar report. Its *suppressio veri* is astounding. For the enormous preponderance of cases to which the comparison would apply is calmly ignored. It is virtually assumed that *all* vehicles on British railways are connected by screw couplings, and the fact is disregarded that the larger number of coupling accidents occur with the goods waggons which have not screw couplings, such vehicles numbering considerably over one million! Another material fact suppressed by the official writer is that in America the vacuum pipes are now made to connect automatically. These cogent facts, which are suppressed or perverted, either unwittingly or of deliberate intent, "knock the bottom out of" his whole argument against automatic couplings. More will yet be heard of this matter.

Speed of Express Trains.

A great deal has been written in the technical journals recently upon the speed of express trains in England and on the Continent, in which it has been sought to show that in the matter of speed the important Continental express trains are ahead of ours. In this connection the following figures relating to the Great Western Railway Company's express run from Exeter to London may be of interest. On Wednesday, the 22nd October, the train due out of Exeter 12·5 p.m. started 6½ minutes late, and drew up at Paddington one minute in advance of time. The following are the times and distances at the more important points on the journey, together with the average speed between those points :—

	Times.	Distances. Miles.	Miles.	Average speed miles per hour.
Exeter	12.10½			
		31¼	31·25	48·7
Taunton	12.49			
		75¾	44·5	58·05
Bristol (Loop) ..	1.35			
		87	11·25	45
Bath	1.50			
		116¾	29·75	46·98
Swindon ..	2.28			
		140¾	24	62·61
Didcot	2.51			
		158	17·25	70·17
Reading	3.5¾			
		175½	17·5	66·68
Slough	3.21½			
		193	17·5	66·68
Westbourne Park	3.37¼			
Paddington ..	3.39 (at rest at platform)			

The average speed over the whole journey, that is to say, from Exeter to Westbourne Park, was 56·3 miles per hour, but at times the speed very greatly exceeded any of the speeds recorded above. For instance, on the down gradient just before coming to Taunton Station, the speed for about six consecutive minutes was nearly 73 miles per hour. This is an excellen performance, more especially as there were one or two slight checks by signal.

BUSINESS SYSTEM AND ORGANISATION.

BY

D. N. DUNLOP.

IV.—COST-KEEPING.

We have, in these articles, fully demonstrated the importance of cost-keeping in all factories or works; therefore the system here described, which has been in practical operation at a large engineering works, and has been kindly communicated through the courtesy of Mr. Albert E. Aspinall, cannot fail to prove of value in factory organisation.

In this case the wages department is controlled by the chief cost clerk. The cost department consists of two sections—i.e., the *Productive section*, in which all accounts, stocks, and wages, connected with the manufacture of the goods are dealt with, and the *Upkeep section*, which concerns itself with the cost of keeping up the plant, running machinery, making alterations and additions to buildings, and all other amounts which cannot be charged to any of the jobs being put through the shops as a direct debit, but which are apportioned at percentage rates.

METHOD OF HANDLING ACCOUNTS.

All accounts rendered, after having been checked in the purchasing department, are passed on to the cost clerk's department, where they are analysed, and the various amounts debited to the proper accounts in the impersonal ledger. Here the direct debits are also charged to the various jobs on hand.

STOCKS.

It is of the utmost importance that the stocks of materials in large engineering and other works should be kept in the most perfect manner.

The principal stocks at the works under consideration are: (1) general stores, (2) fuel, (3) pig-iron, (4) building materials, (5) ganister, (6) limestone, (7) tools. The various articles required by the departments are requisitioned from the stores-keeper, by the heads of departments, on special dockets, one for each material; the stores clerk posts up the dockets and keeps an exact account of all stores received or given out. At stated intervals he examines the contents of the bins and pigeon-holes, checking their contents by his ledger. This method saves much trouble at the annual stock-taking, as the ledger is kept posted up week by week, and prevents the disastrous running short of articles, which may cause delay in the execution of an order placed under penalty in the contract.

In addition to the stores-keeper and his assistant-clerk, each department has its stock-keeper, who daily posts up all stores received or returned.

TOOLS.

A stock is kept of all tools purchased, and, in the case of large machine tools, amounts are written off periodically for depreciation, and charged to the jobs in hand under the head of cost of production. Small tools are handed out as required, and if lost by a workman are usually deducted from his wages in weekly instalments.

COST BOOKS

or job books generally allow job number for every job in a contract, and all items connected with each job bear that number. The use of different coloured inks for the wages posting of each week has been found advantageous.

A practical and experienced cost clerk may be considered an invaluable assistant to the manager, and should be chosen with the greatest care. He has means at his disposal for ascertaining accurately at a given moment all data concerning cost incurred in any department. The cost clerk looks at all matters from the £ s. d. point of view, and is always on the alert to discover any leakage in wages or material in any job passing through the works; he can detect any want of discretion or good judgment in the foreman or others in charge of any specific job. The cost clerk must be a man of more than average intellect, and has to figure out the most intricate problems of the management, which if unsolved would seriously perplex and hamper the manager, who is anxious that his cost of production should show a good margin for profits and compare favourably with past

CRUSHING PLANT COST SHEET.

For Week ending ....190 ...

Material Crushed.	T.	C.	Q.	Total cost per Ton crushed.
Matte				
Ore				
"				
"				
"				
"				
Total				

Wages.	Amount.			Totals.			Cost per Ton crushed.
LABOUR—							
Foreman							
Motormen							
Transporterman							
Labour in Crushing Plant ...							
Sundry Labour							
Total							
GENERAL—							
Fitters and Smiths							
Electricians							
Timekeepers, &c.							
Exceptional Charges							
Salaries and Sundries							
Total							
SUNDRIES—							
Tools							
Castings							
Stores							
Casks							
Bags							
Total							
PROPORTIONATE CHARGES—							
Electric Power							
" Light...							
Traffic							
Total							
Grand Total ...							

A column is provided on the right-hand side of sheet for remarks.

records. The cost clerk endeavours to acquire as much technical and practical knowledge as possible of all the manufactured articles produced by his firm. There is, in fact, no limit to his achievements or experience.

Mr. Aspinall has tried, with admirable success, a system of weekly cost sheets in large electrically-driven smelting works, laid out in the following manner :—

On the wharf, which has storage bins and crushing plant adjoining, a transporter was erected for conveying material to the bins from the ships' holds. Automatic railways also ran the length of the bins, each of which was in addition provided with a revolving-table weighing machine, which weighed every load before skidding it into the bins.

Large crushing mills were erected in sheds adjoining, and the ore, crushed to the required size, was returned to the bins and kept as stores to be issued on requisition. The cost sheet of the crushing department shows in the top section "material crushed," the weight of ore crushed, and the total cost per ton for crushing.

From the analysis of wages, the various debits were collected and placed in the column provided, together with items of general expense apportioned for the week. The cost per ton was worked out under the headings of *labour*, *general*, *sundries and proportionate charges*, the total giving the net cost for crushing. (See figure.)

All charges for unloading the various ores were at once charged in the ledger account against *ores*, to be used as value for ores at stock-taking times.

THE CALCINING DEPARTMENT.

This consisted of revolving plough-geared self-discharging calciners, from whence the ore was passed on to the briquetting department, where, after being mixed with certain fluxes, the material was put through the briquetting press, and discharged by means of a belt into trucks, which conveyed it to the weighing-machine. It was then passed to the

SMELTING DEPARTMENT.

Here the waggons of material were raised to charging platforms by hoists, and charged into the furnace cupola with a proper proportion of flux and coke. The cupola was fitted with two lips for slag and for metal, and the slag was run out into slag pots, wheeled away, and tipped. The metal was run off into moulds. After cooling, the slag was broken up and passed along to the Siemens' furnace or zinc plant department.

For obvious reasons, the cost sheet for the smelting department also takes care of the calcining and briquetting. The costs are, of course, based on *raw weights*, as the first weight is considerably reduced after the moisture has been driven off.

Each section is treated in detail, as in figure, which will serve as a guide. Practical illustrations such as these are of more value to managers than any costly conference summoned to ascertain costs.

SIEMENS' FURNACE OR ZINC PLANT DEPARTMENT.

This plant consisted of eight furnaces, designated by the first eight letters of the alphabet. Here the slag was treated for zinc contents, the fumes driven off being collected in the form of dust in chambers adjoining. The slag was tipped into large steam self-tipping ladles, and dumped on to the slag bank; the material recovered being passed afterwards through the smelting furnace.

In the cost sheet the same manner of treating the debits under different headings is to be noted.

A glance at the summary reveals the object. A works manager would ask his department manager what material had been put through the furnace during the week; what quantities had been recovered, and what were the costs of production. The cost sheet provides the answers in concise form, instead of the usual exasperating approximate figures still tolerated in some works. (See figure.)

All company directors would do well to demand *weekly comprehensive working cost sheets*, which could be handed round for inspection, affording ample scope for conference, and insuring a greater proportion of profits eventually to the shareholders.

ELECTRIC POWER STATION.

Two 400 kilowatts D.C.A.C. Allis Crocker Wheeler sets, switchboard (two distributing and two feeder panels), three batteries, and Babcock boilers with automatic stokers were utilised. The coal was fed by gravity from bins into the hoppers of the stokers.

SMELTING COST SHEET.

For Week ending .... 190..

CALCINING COSTS.

Furnace Working.	Materials Calcined.	T.	C.	Q.	Moisture. %	T.	C.	Q.	Dry Weight. T.	C.	Q.	Analyses. Pb.	Zn.	S.	Ag.			Final Sulphur %	Calcined Weights (estimated). T.	C.	Q.
	Stock of Calcined Material—																				

Costs.	T	C	Q	Rate	£	s.	d.	Cost per ton of Raw material
FUEL.								
Coal								
Slack								
SUNDRIES.								
Tools								
Stores, &c.								
Bricks								
Fireclay								
Castings								
Proportionate Charges								
Electric Power								
Electric Light								
Water Pumping								
Traffic prop.								
direct debit								
Carried forward								

Costs—Contd.	£	s.	d.	£	s.	d.	Cost per ton of Raw material	Remarks.
Brought forward								
WAGES.								
Foremen								
Furnacemen								
Feeders								
Gantrymen, top								
Lift Attendant								
Labourers								
Motormen								
Charge Loaders								
Weighers								
Stock Loaders								
Timekeepers, &c.								
Fuel Loaders								
GENERAL.								
Fitters & Smiths								
Exceptional Charges								
Salaries & Sundries.								
Laboratory Charges.								
Grand Total								
Total Cost per ton								
Of Dry Raw Material .. £								
Of Dry Raw Ore .. £								

BRIQUETTING COSTS.

Materials used.	T	C.	Q.	Briquettes.	T	C	Q.
Calcined Ore				Briquettes made			
Flue Dust				,, in stock			
Calcined Matte							
Salt Cake							
Nitre Cake							
Purple Ore							
Lime							

Costs.	£	s.	d.	Cost per ton.
SUNDRIES.				
Tools				
Stores &c.				
Castings				
Proportionate Charges				
Electric Power				
Electric Light				
Water Pumping				
Traffic prop.				
,, direct debit				
Carried Forward				

Costs—Continued.	£	s.	d.	£	s.	d.	Cost per ton.	Remarks.
Brought forward per ton.								
WAGES. T C Q								
Contractors								
Gantrymen								
Lift Attendant								
Charge Loaders								
Weighmen								
Labourers								
Stock Loaders								
Motormen								
Timekeepers &c.								
GENERAL.								
Fitters & Smiths								
Exceptional Charges								
Salaries & Sundries								
Grand Total								Cost per ton of Briquettes
								,, ,, Dry Raw Ore

SMELTING COSTS.

Materials Treated.	T	C	Q	Metallic Contents. Au. ozs.	Ag. ozs.	Pb. %	Zn. %				Total Weights of Metals. Au. ozs.	Ag. ozs.	Pb. tons.	Zn. tons.				Recovery	Remarks.
Briquettes																			
Matte																			
Slag																			
Roasted Ore																			
Total																			
Equivalent in Dry Raw Ore																			

Recovery	T	C	Q	Lbs
Lead				
	Ozs. per ton of Lead		Total Ounces	
Silver				
Gold				

	T	C	Metallic Contents Ag.	Pb.	Zn.	Fe.	
Matte							
Slag							

Costs.	T	C.	Q.	Rate.	£	s.	d.	Cost per ton of Raw Ore Smelted.
FUEL.								
Coke								
Charcoal								
Total								
FLUXES.								
Purple Ore								
Salt Cake								
Limestone								
Burnt Ore								
Lime								
Total								
SUNDRIES.								
Tools								
Stores &c.								
Bricks								
Fireclay								
Castings								
Slabs								
Total								
Carried Forward								

Costs—Continued.	£	s.	d.	£	s.	d.	Cost per ton of Raw Ore Smelted.
Brought forward							
Proportionate Charges							
Electric Power							
Electric Light							
Water Pumping							
Traffic prop.							
,, direct debit							
Total							
WAGES.							
Foremen							
Gantrymen							
Feeders							
Forehands							
Furnacemen							
Lead Dippers							
Slag Haulers							
Prop. of Loading Slag							
Charge Wheelers							
Stock Loaders							
Motormen							
Blower Attendants							
Weighmen &c.							
Sundry Labour							
Timekeepers &c.							
Total							
Carried Forward							

Costs—Continued	£	s.	d.	£	s.	d.	Cost per ton of Raw Ore Smelted.	Remarks.
Brought forward								
GENERAL.								
Fitters and Smiths								
Exceptional Charges								
Salaries & Sundries								
Laboratory Charges								
Total								
Grand Total								
Calcining Cost								
Briquetting Cost								
Smelting Cost								
Total Cost								

.... *Department Manager*

.... *Works Manager*

Date.............................. ..190

ELECTRIC POWER and LIGHT PLANT COST SHEET.

For Week ending ....

[illegible]	[illegible]	[illegible]	Rate	Amount	Cost per B.T.U. or E.H.P. hour	Remarks
FUEL						
Boilers						
Coal Elevator Crane ...						
Deduct fuel for steam for hammers in Smithy						
Total						
WATER for boiler feeding and condensing	gallons					
From Canal						
Works Supply						
Total						
SUNDRIES						
Stores						
Tools ...						
Renewals and Repairs (material), Station Lights, Incandescent lamps, Carbons, &c.						

Average reading of Station Voltmeters ...		
" " " Ammeters		
" I H P produced		
" E H P generated ...		
Total B T U " ...		
STATION SWITCHBOARD		
Average E H P used in Station for motors and lights		
Total B T U " " " ...		
Average E H P distributed to works ...		
Total B T U " " ...		
WORKS FEEDER PANELS		
Average E H P used for power in works		
Total B T U " " "		
Average E H P " light "		
Total B T U " " "		
COST OF POWER AND LIGHT		
Cost per E H P hour		
" I H P "		
" B T U generated		
Average coal used per I H P		lbs
" E H P		"
" B T U		"
Number of days Station working		

Wages	Amount	Totals	Cost per B T U or E H P Hour	Remarks
ENGINE ROOM				
Drivers ...				
Greasers				
Cleaners				
Boys				
Switchboard Attendants ...				
Total				
BOILER ROOM–				
Firemen				
Trimmers and Ashwheelers				
Boiler Foreman (propn.) ...				
" Cleaners				
Total				
COAL ELEVATOR–				
Driver				
Labourers				
Total				
GENERAL–				
Fitters, Smiths, &c.				
M. Engineers Salary (propn.) ...				
Electricians " " (") ...				
Exceptional Charges				
Total				
Total cost for Power and Light Plant ...				
ARC AND INCANDESCENT LIGHTING MATERIALS				
Carbons for Lamps (Arc) ...				
Globes " " (") ...				
Incandescent Lamps ...				
Sundries and repairs to Lamps				
Total				
WAGES–				
Lamp Trimmers				
Electricians (Propn.) ...				
Total				

Departments debited	Feeder Panel No.	Average E H P used.		B T U consumed.		Amount debited.		Remarks
		Power	Light	Power.	Light	Power.	Light.	
Zinc Plant and Yard								
Cupola and Yard								
Briquetting Department ...								
Calcining "								
Wharf, Bins, and Crushing								
Fitting Shop and Smithy								
Total								

....

....
Engineer and Works Manager.

.... 190

ZINC PLANT COST SHEET.

For Week ending 190

MATERIAL TREATED	Gross Weight.			Moisture. %			Dry Weight.			Zinc %	Lead %	Silver. ozs. per ton.	Remarks.
	T.	C.	Q.	T.	C.	Q.	T	C.	Q.				
Slag Charged—A Furnace													
" B "													
" C "													
" D "													
" E "													
" F "													
" G "													
" H "													
Total													

MATERIALS USED.	T.	C.	Q.	Rate.	Amount.	Cost per ton of Slag.
FUEL—						
For Furnaces						
" Boilers						
" Ladles						
Total						
ADDITIONS TO CHARGES—						
Anthracite Duff...						
Coke Breeze						
Stirring Poles						
Limestone						
Lime						
Pig Iron..						
Total						
REFRACTORY MATERIALS—						
Dolomite						
Chrome Ore						
Tar						
Total						
SUNDRIES—						
Tools						
Stores, &c.						
Bags						
Total						
PROPORTIONATE CHARGES—						
Electric Power						
Electric Light						
Water Pumping...						
Traffic Prop. :—						
" Direct Debit						
Total						
Grand Total carried forward						

WAGES.	Amount	Totals.	Cost per ton of Slag.	Remarks.
Brought forward... ...				
FURNACES—				
Foremen				
Furnacemen .. .				
Helpers				
Gasmen				
Chargers and Graters ...				
Ladlemen				
Gantrymen, Top ...				
" Bottom ..				
Boiler Firemen				
Millmen				
Weighers . ., .				
RECOVERY PLANT—				
Foremen				
Flue Cleaners . .				
Warehousemen .				
Motormen .. .				
Pitmen				
Coopers . . .				
Bagging and Stocking Oxide				
Sundry Labour . .				
GENERAL—				
Fitters and Smiths.. .				
Timekeepers, &c. . .				
Salaries and Sundries				
Laboratory Charges . .				
Loading and Unloading Slag				
Total Wages ..				
Total Costs ...				
Cost per ton of Slag Charged .				

RECOVERY.

	Zn. %	Pb. %	Ag. ozs. per ton.	T.	C.
Zinc Oxide Recovered...					
" "					
Total Oxide Recovered ..					
	Zn. %.	Fe. %.	Ag. ozs. per ton.	T.	C.
Matte Recovered					

STOCK.

SUMMARY.

	T.	C.
Total Slag Charged		
" Oxide Recovered		
" Matte "		
Cost per ton of Slag treated ...		

Department Manager.

..............190

Works Manager.

FORMS USED IN CHARGING BOOKS.

DEPARTMENT.

[illegible]	[illegible]	Sun.	Sun. N.	M	M. N.	Tu.	Tu. N.	W.	W. N.	Th.	Th. N.	Fri.	Fri. N.	Sat.		

Week Ending..

			Total Shifts and Hours.	Rate.	Amount.	Extension.

Fig. 4A

FUEL STOCK.

[illegible]	Colliery	Waggon No.	Thro' Coal.			Screened Coal			Slack.			Coke.			Coke Breeze.			Where unloaded.
			T.	C.	Q.	T.	C.	Q.	T.	C.	Q.	T.	C.	Q.	T.	C.	Q.	
	Brought Forward																	

FUEL DISPOSALS.

Date [illegible]	Department Debited	Thro' Coal.			Screened Coal			Slack.			Coke.			Coke Breeze.			Remarks.
		T.	C.	Q.	T.	C.	Q.	T.	C.	Q.	T.	C.	Q.	T.	C.	Q.	
	Brought Forward																

The working cost sheet provides complete analysis of the cost of working the power plant. (See illustration.)

The following method is adopted for calculating the extensions and the power and light which are placed on the left hand side of the sheet :—

$$\frac{\text{Total amperes} \times 250 \text{ volts} = \text{B.T.U.}}{1000}$$

÷ by number of hours worked = units per hour.

$$\frac{\text{Total amperes} \times 250 \text{ volts} = \text{E.H.P.}}{746}$$

÷ by number of hours machines have run = average units per hour. The weight of coal in lbs. ÷ by number of hours engines have run = lbs. of fuel consumed per hour. Total weight of coal consumed × B.T.U. or E.H.P. = fuel consumed per unit hour.

There were in addition large fitting shops, smithy and general stores. A well equipped laboratory adjoined the general offices.

TIME-KEEPING.

Without a good system, time-keeping becomes a source of great anxiety and worry to the manager, and he is continually troubled by reports of discontent over the wages roll on the part of the workmen, who must be made to feel that their time is well and accurately looked after. The following system was in use at the works here described, all departments of which were run with three shifts. An average number of 750 men was employed, the check system of round and square checks for alternate weeks being in force.

The day men lifted their check on entering the works in the morning, at breakfast and dinner hours, pushing them through the slot indicated by the time-keeper, who took up a position directly opposite the tally boards and carefully noted that each man only raised one check for himself. The tally boards had the number clearly painted on them, and the lighting was such that the workman could at any time easily discern the number on his check. The foremen were provided with pocket-books, conveniently ruled, which they used on alternate days for noting the nature of the work upon which their workmen were engaged. These books were deposited each evening in the time office to be entered into the charging books (figs. 4a and 4b). The time-keepers, in addition, went round the works at given times during the day checking against the foremen.

The time of the shift men was checked in the same manner, and the department managers' clerk took the men's time independently and checked it with the time-keeper. The total shifts and hours on any job and the overtime were totalled up, and the amounts carried out in the extension column. Simplicity, thoroughness and reliability are claimed for this system, and in case of dispute ready reference is always available.

FUEL STOCK AND DISPOSAL.

The object of the fuel stock and disposal book is to record the receipt and disposal of the whole of the fuel needed for the furnaces, power stations and other purposes. The figures are checked up every week, and the tonnage used is debited to the various departments. There are, in addition, *smithy debits*, *stores debits*, and *timber debits* books all ruled according to requirements.

GENERAL REMARKS.

A smart manager will leave no stone unturned until he has obtained complete returns of the cost of each department. An efficient staff in the costs department is expensive, but the useful work done amply compensates the firm for the salaries paid. No factory should start a cost department unless it can afford a thoroughly efficient staff. An expert cost clerk has to study his work morning, noon, and night. It is well for the manager to be able to turn over to him the foremen who continually come to consult him on matters concerning the jobs on hand; with the help of the chief draughtsman there is little concerning the work of production which he cannot settle. This will prevent many stoppages of work which occur while the foremen are waiting to consult the manager. It is the cost clerk's business to record all such delays and their cause, and to charge the loss under the proper heading. In short, if a manager once secures a good cost clerk, he will find him an excellent investment.

In conclusion, we would say, take care of the costs and the dividends will take care of themselves. The manager is responsible for the output, and, indirectly, for the dividends also.

AMERICAN RÉSUMÉ.

BY OUR NEW YORK CORRESPONDENT.

NEW YORK, 15th November, 1902.

Steel Industries and Coal Strike.

THE iron and steel industries have been very much upset during the past month by the record-breaking anthracite coal strike, [illegible] almost unprecedented harvest of grain [illegible] general. The strike has, of course, [illegible] crippled the pig-iron producers who [illegible] on anthracite coal, and seems to have [illegible] itself greatly felt among the larger number [illegible] who use coke. While the output [illegible] pig-iron has been considerably less than that [illegible] previous months, there was a demand that [illegible] not have been supplied even if there had [illegible] no strike. The resulting large importation [illegible] pig-iron is well known. Not the least serious [illegible], however, in connection with this business is the threatened blockade of the railroads, [illegible] are now heavily involved in moving grain. [illegible] is believed in some quarters that not only will [illegible] railroad blockades extend throughout the [illegible]ter, but that the ordinary maximum pro[illegible]tion of pig-iron will not be reached till spring. [illegible] outlook is that large importations will [illegible]tinue throughout this period.

[illegible]hat has been said regarding pig-iron applies [illegible]lly well to steel billets. The demand has [illegible] much greater than the supply, and a large [illegible]unt of foreign orders are said to have been [illegible] particularly with German manufacturers. [illegible] connection an interesting customs decision [illegible]ndered in Philadelphia respecting the duty [illegible]rman billets. It was asserted that the [illegible] on the cost of the products [illegible] the prices made specially for export business. Exception has been made to this ruling, but as yet no authoritative statement has been made public.

With regard to finished iron and steel, an unusual state of affairs presented itself during the latter part of September. While all the pig-iron and steel billet establishments were pressed to the utmost for deliveries, an overproduction occurred in the wire, wire-rod, pipe, sheets and tinplate market. Quite a number of the mills have had to close to await a sufficient demand. In structural shapes the demand is very heavy, and there is much business in merchant bar and steel plates. Steel rails are also in very heavy demand.

The general condition of the iron and steel industries, as here briefly outlined, has called attention to the new state of things in the States. Whereas but a short time ago Europe was looking askance at the so-called American invasion, now prices are generally high and the country is altogether occupied in attempting to meet its own requirements. The balance of trade between the United States and Europe has changed so much that the term " invasion " is becoming ridiculous. According to the report of the Bureau of Statistics the excess of exports over imports was $16,000,000 for September, against $35,000,000 for August. It is interesting to contrast the period of low prices in 1898, when American manufacturers sought business abroad, as typified in the famous Atbara bridge contract, with the state of things now existing, as indicated by the recent assertion that one-half of the pig-iron production for the first six months of 1903 has already been sold at prices probably one-half as high again as those in the corresponding six months of the present year.

A New Water-power Plant.

The formal opening, on October 25th, of the water-power plant on the Michigan side of the St. Mary's River marks the completion of a wonderful engineering undertaking, and brings forcibly to mind the possibilities of foresight and endeavour. In 1894 the water-power rights of the river, which carries the discharge of Lake Superior into Lake Huron, amounting to 3,500,000 to 7,000,000 cubic feet per minute, were purchased for what is now the Consolidated Lake Superior Company. Since that time a varied number of industries have been established by the company, each addition owing its existence to the desirability of meeting the needs of a predecessor, a large industrial town has arisen, and two water-power plants on opposite sides of the river have been developed, yielding together 80,000 h.p. The American plant is of 60,000 h.p. capacity, and comprises 320 thirty-three-inch turbines, working under a head of something less than 20 ft. The water is led to the power-house through a canal starting from a bay 2,900 ft. long, 950 to 220 ft. wide and 22 ft. deep, cut in the solid rock. The canal is 200 ft. wide, but as it approaches the power-house, expands to 1,400 ft. The power-house acts as a dam in which the turbines are located, and is 1,368 ft. long and 100 ft. wide. For its foundation 1,200 piles 50 ft. long were required, and in the construction of power-house and canal 1,250,000 cubic yards of rock and 3,000,000 cubic yards of earth were excavated, 3,500,000 ft. of piling were used and 900,000 cubic yards of masonry and 170,000 cubic yards of concrete were constructed.

A Recent Addition to the United States Navy.

The *Des Moines*, an armoured cruiser for foreign port protection, was launched on September 20th, at the yard of the Fore River Ship and Engine Company, Quincy, Mass. She is 308 ft. 2 in. long, 292 ft. on the load water line, and 44 ft. broad. She has a displacement of 3,200 tons, with a mean draft of 15¾ ft. Her main engines, two in number, are of the four-cylinder triple-expansion type, having 4,700 i.h.p.; and her boilers, six in number, are of the water-tube type, provided with 300 square feet of grate surface and two stacks, 70 ft. high above the grates. Her accredited speed is 16·5 knots. Bunker capacity has been provided for 700 tons of coal. The hull below water and under the sheet-copper covering is of Georgia pine, bolted with bronze bolts to the steel shell. The flat deck is of 5·16 in. steel: the slopes, opposite the engines and boilers, of 2½-in. nickel steel. Her armament will include ten 5-in. 50-calibre rapid-fire guns, eight 6-pounder guns, two 1-pounder guns and four Colt automatic guns, besides one field gun. Smokeless powder is to be used, and the magazine will hold 250 rounds for each of the 5-in. guns and 500 rounds for each of the 6-pounder guns. Her two masts will carry some 6,000 square feet of canvas, and one of them is to have a "wireless" telegraph attachment.

The Standardisation of Fittings in the U.S. Navy.

The standardisation of the fittings of ships built for the U.S. navy by private shipbuilders has apparently made much progress. Referring to this subject in his annual report, Rear-Admiral Francis T. Bowles, chief of the Bureau of Construction and Repair, says that the builders, having on their own initiative organised a conference on the subject, finally submitted plans of fittings which they recommended for adoption as standards. During the year, forty-four such standards were established, including water-tight manholes, water-tight doors, air ports, coal scuttles, deck lights, warping and towing bitts, lift and force pumps, water-tight hatches, pipe flanges, portable ventilators, metallic ladders and boat davits. In addition, general specifications for electrical appliances on board ship have been adopted, together with standard alloys of copper, tin and zinc.

The Use of Oil Fuel in Marine Engines.

The Liquid-Fuel Board, which has been conducting an elaborate series of experiments on the use of oil in steam boilers for the Bureau of Steam Engineering, has presented its report, although it appears that there is still [illegible] to accomplish. [illegible] generator can be [illegible] with coal; [illegible] down on the boiler; [illegible] used to favour oil, and [illegible] will be met with in this [illegible] requisite for combustion [illegible] heated before entering the [illegible] undoubtedly assists the [illegible] product: that the oil [illegible] that it can be atomised more [illegible] using steam for atomising [illegible] results are more advantageous [illegible] and that the consumption [illegible] cannot be forced to so [illegible] with steam as the atomising [illegible] compressed air is used for this [illegible] probably due to the fact that [illegible] supplies oxygen for the com- [illegible] of steam, the rarefied [illegible] that is needed to complete [illegible] Under heavy forced-draft con- [illegible] only when steam was used, the [illegible] possible to prevent smoke from [illegible] The average percentage [illegible] for atomising the oil was about [illegible] the entire evaporation, this per- [illegible] as higher pressures [illegible] is stated, a greater evapo- [illegible] under those conditions.

[illegible] Cement.

[illegible] valuable information has [illegible] recently appeared in the report [illegible] the Insurance Engineering Experiment Station at Boston. [illegible] the protection afforded to steel [illegible] concrete. A considerable [illegible] begun in December, 1901, [illegible] under the direction of [illegible] engineer in charge [illegible] and sand were used [illegible] with different cements, [illegible] of different [illegible] it will be im- [illegible] the character or [illegible] that where [illegible] was found as [illegible] the more porous [illegible] alternate bright and badly rusted areas. In both the solid and the porous cinder concrete, many rust spots were found, except where the concrete had been mixed very wet, in which case the watery cement had coated nearly the whole of the steel and protected it. The conclusions are that concretes, to be effective in preventing rust, must be dense and without voids or cracks; that they should be mixed quite wet when applied to metal; that the corrosion in cinder concrete is mainly due to the iron oxide in the cinders and not to sulphur; that cinder concrete, if free from voids and rammed wet, is about as effective as stone concrete; that the steel should be clean, scraping or pickling it, if necessary, or using the sand blast. Professor Norton believes that the coating of all steel work with cement before applying concrete, tile, or brick is an absolute essential, if the formation of rust and consequent weakening of the steel is to be prevented. The thickness of the cement layer need not be great, but it should be a continuous coating, without cracks.

The Safe Speeds of Flywheels.

The attractive subject of flywheels and their safe speeds has been recently studied by Mr. William H. Boehm, of the Fidelity and Casualty Company, New York. On the basis of the following formula for the speed—that the peripheral velocity of the rim of the wheel in feet per second is obtained by dividing the tensile strength of the material by its weight per cubic inch, extracting the square root of the quotient and then multiplying by 1·6—he obtains the following figures: for cast iron, allowing 10,000 lbs. per square inch as the ultimate strength of large castings, and adopting a factor of safety of 10, a safe speed of 100 ft. per second. This is for wheels in one piece. For cast steel, with an ultimate strength of 60,000 lbs. per square inch, and weighing 0·28 lb. per cubic inch, the safe speed, with a factor of safety of 10, becomes 233 ft.; that is, 2·66 miles per minute. For hard maple, with a tensile strength of 10,500 lbs., weighing 0·0283 lb. per cubic inch, and with a factor of safety of 20, the rim being built up of segments, the safe speed proves to be 154 ft. per minute.

Nitrates from Air.

One of the most interesting developments to report in the field of electricity relates to the fixation of the nitrogen in the air. This work, which means the production on a commercial basis of nitric acid or of nitrates by securing the combination of nitrogen and oxygen in the air, has been achieved by Mr. Charles F. Bradley and Mr. D. Ross Lovejoy, president and electrician, respectively, of the Atmospheric Products Company, of Niagara Falls. According to details recently given out, the essential part of the system is a nitrifying chamber, a cast-iron cylinder about 4 ft. in diameter and 5 ft. high, within which 138 electrodes distributed in 23 levels are revolved about a central vertical shaft. There is a corresponding number of stationary electrodes, with which the revolving electrodes set up arcs, in six vertical rows of 23 each. Six air passages at each of the six rows of stationary electrodes, provide for drawing off the air as fast as it is subjected to the influence of the arc. The scheme is an application of the fact that oxygen and nitrogen can be made to combine by means of the electric arc. The direct current was found more satisfactory than alternating currents. Minimum current, with minimum heat expenditure, and maximum arcing surface are obtained by separating the electrodes quickly after the arc has been formed, which occurs with the 8,000 volts used at a distance of $\frac{1}{16}$ in. To resist a rise in current during the early part of the arc, and to assist in prolonging it in the latter dart, an inductance coil is inserted in each circuit. The arc breaks when it reaches a length of 6 in. to 8 in. The speed of the central shaft is 300 revolutions per minute, so that 414,000 arcs are formed per minute, each of which receives 0·005 ampere. The air passes from the nitrifying chamber through the six channels to a galvanised iron tank, where the nitric oxide is given time to take up more oxygen, and it is then conducted into a stand pipe filled with coke. If nitric acid is to be formed, water is delivered into the top of the pipe, trickling over the coke; if nitrates are to be made, a solution of caustic alkali, potassium hydrate for example, is introduced. Air is passed through the apparatus at the rate of 3 to 4 cubic feet per minute, and about 3 per cent. of the nitrogen is oxidised. Experiments are now being carried on to determine the proportion of oxygen to be added to the air that will, as is believed, give a higher percentage. The company intends before long to operate the works on a large scale.

Improved Conduits for Electric Wires.

Recent accidents due to the joint use of underground conduits for high and low-tension electric distribution systems have called forth a paper on the subject by Mr. Charles F. Hopewell, which was read before the International Association of Municipal Electricians, at Richmond, Va. Faulty methods of construction, he considers, comprise all kinds of conduits built of conducting material, such as iron pipes or ducts with an iron covering, where joints every 8 ft. place the cable in contact with iron rings metallically connected to such iron covers. A break-down of insulation immediately charges the entire conduit from manhole to manhole. He advocates the use of non-conducting and permanent material, preferably of tile; single ducts, for high-tension wires; the multiple type for low-tension wires. The low-tension ducts should be laid on top of the high-tension ducts, separated therefrom by 6 in. of concrete cement. The entire system should be imbedded in 3 in. of concrete with 1-in. planking on top. One set of manholes should be used for all high-tension wires, these also containing transformers, and a separate set for the low-tension wires.

Electrolytic Refining of Base Lead Bullion.

Some details of a system for the electrolytic refining of base lead bullion have recently been made public by Mr. Titus Ulke in the columns of the *Engineering and Mining Journal*. In view of the highly satisfactory results which have been attained, a brief résumé will be interesting. This system, which was invented by Mr. A. G. Betts, has been applied to a plant of ten tons daily capacity at Trail, British Columbia. The depositing room contains 20 tanks, built of wood and lined with tar. The anodes consist of the lead bullion cast into plates about 2 in.

thick; the cathode sheets, which receive the lead deposit, are thin lead plates obtained by electro deposition upon and stripping from special cathodes of sheet steel. The process is based on the easy solubility of lead in an acid solution of lead fluo-silicate, which possess both stability under electrolysis and high conductivity. The electrolyte is obtained by diluting hydrofluoric acid and saturating it with pulverised quartz. The electrodes are separated by a space of 1½ in. to 2 in. The fall in potential is about 0·2 volt; 10 to 25 amperes per square foot are allowed. One ampere deposits 3·88 grams of lead per hour. At 10 amperes per square foot, the cathode area should be about 1,080 square feet per ton of daily output. The total quantity of electrolyte is 175 cubic feet. It is stated that each ton of lead refined requires the burning of 200 lbs. of coal. In the Betts electrolytic process, nearly all the impurities in the base bullion remain as a more or less adherent coating on the anode. This residue consists practically of all the copper, antimony, bismuth, arsenic, silver and gold contained in the bullion, and about 10 per cent. of its weight in lead. Estimating that the electrolyte will have to be purified once a year, the amount to be purified daily figures out less than one cubic foot for each ton of output. The author of the article believes that the development of electrolytic lead refining signalises as great an advance over the fire methods of refining lead as electrolytic copper refining does over the old Welsh method of refining that metal.

American Coal Product.

The coal production of the world, according to the Monthly Summary of Commerce and Finance issued by the Treasury Bureau of Statistics, amounted in 1901 to 866,165,000 short tons. The shares in the production held by the leading countries were as follows: United States, 34 per cent.; United Kingdom, 28 per cent.; Germany, 19·2 per cent. In 1868 the United Kingdom produced over three times as much as either the United States or Germany. The anthracite mining operations of the United States, which have been much before the public on account of the recent strike, are scattered through a narrow region, principally in Pennsylvania, about 90 miles long. The basins are generally of considerable depth, 2,500 to 3,000 ft., with the beds at an angle of 30 deg. with the horizontal. The seams are sometimes 50 ft. or 60 ft. deep, but those of 6 ft. or 7 ft. have proved most satisfactory as mining propositions.

Steel Linings for Mine Shafts.

Lining mine shafts with steel, owing to the growing scarcity of timber, has been the practice of the Oliver Iron Mining Company, in Michigan, for the past two years. The framing is formed of rails, rivetted together by means of angle-irons. Where there is danger of small pieces of rock falling into the shaft, old wire ropes are employed, stretched length-wise of the shaft close enough together to guard against the possible loosening of large rocks. Where a more secure enclosure was indispensable, 2-in. planking has been used. It is understood, however, that corrugated steel is to be used hereafter in such cases, at least every 100 ft., to prevent the spread of fire otherwise favoured by a continuous lagging of wood. No. 16 corrugated steel, which is $\frac{1}{16}$-in. thick, is perhaps the strongest single thickness available, and if galvanised, it should last a long time.

PAGE'S MAGAZINE

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OUR MONTHLY RÉSUMÉ.

LONDON, 20th November, 1902.

Giant Steamers.

ALTHOUGH there is no improvement in the demand for merchant ships, there seems a growing demand for size. The orders for the two new giant Cunarders to be built under the £150,000 subsidy agreement with the British Government have not yet been placed, while these lines are being written, but it is believed that one will be ordered on the Clyde and the other on the Tyne. Belfast is out of the running in this case, but Belfast has booked the first order from the Morgan Combine, who are bound to take all their new ships from Messrs. Harland and Wolff, so long as that firm can supply them. And from Messrs. Harland and Wolff the Atlantic Transport Company, which is part of the Combine, has just ordered three steamers of 12,000 tons each for the traffic between London and New York. These boats will have names with the "Minnie" prefix favoured by this Company. The Atlantic Transport boats will do the work of the Combine between London and Boston, while the old Leyland boats will run between Manchester and Boston. There is no want of activity in shipbuilding at Belfast, and the Clyde yards (or most of them) are still tolerably well employed, though their order books are running out. But in the North of England there is a decided and increasing depression and a gloomy outlook for the winter months.

Shipbuilding Prospects.

It is just a question whether a reduction in costs would bring forward a new series of contracts just now, or whether the freight markets are so low as to discourage all building of vessels of the "tramp" order, which really do the carrying trade of the world. The run of American orders for coal sent up freights from 7s. to 10s., or so, from the North-East of England to United States ports. With the termination of the anthracite strike, the orders from America for coal stopped and freight came quickly back to 7s. Then the shipment of pig-iron was resumed. Now, if it were not for the American demand, it is probable that pig-iron would be 10s. or more per ton lower than it has been for quite a number of months. If pig-iron were to decrease into the lower "forties," we might see steel ship-plates down to a tempting price, but at £5 10s. per ton, less 2½ per cent., in Middlesbro', and £5 15s. less 5 per cent., in Glasgow, they are not low enough to enable builders to cut fine. It is not likely that iron will come down much for some months to come, and it is probable that shipbuilding will be quiet all next year.

The Brown and Firth Combination.

An important development of the past month has been the amalgamation between the shipbuilding and steel manufacturing concern of John Brown and Co., Ltd., of Clydebank and Sheffield, with that of Thomas Firth and Sons, Ltd., steel manufacturers, Sheffield. The alliance is not a fusion of the two companies into one, but an exchange of shares, much on the same principle as the formation of the "community of interests" between Vickers, Sons, and Maxim, Ltd., Barrow and Sheffield, and William Beardmore and Co., Ltd., Glasgow. At all events, John Brown and Co. take seven-eights of the shares of Thomas Firth and Sons, and pay for them with their own shares. As ordnance and gun-mountings are made at the Firth Works, the new combination will be able to turn out a fully-armed and equipped warship from the raw material. It was boasted of the new American Shipbuilding Syndicate that it was the only concern in the world that could do this. As a matter of fact we have now three private establishments that can do it—the Armstrong Company, the Vickers and Beardmore alliance, and the Brown and Firth combination.

A New Departure.

A new departure in shipbuilding since our last notes is the steam yacht *Emerald*, which Messrs. Alexander Stephen and Sons, Ltd., Linthouse, Glasgow, have built for Sir Christopher Furness. In this vessel marine engineers hope to determine some of the problems raised by the application of the marine steam turbine to the propulsion of ocean-going vessels. The *Emerald* is not the first yacht to be fitted with the new type of engine, but she is so built as to be able to demonstrate the economy of fuel at low speeds with steam turbines, as compared with reciprocating engines. At present, all the vessels in which turbines are used are swift, and doubts are entertained of the economy of using turbines in vessels of low speed. The *Emerald* is not intended for high speed, and as she is, so far as model is concerned, a vessel which will compare well with others of a similar type, the results of the experiment should be of exceptional interest. The intention is to obtain a rate of about 16 knots with an entire absence of vibration, and an exceptionally low coal consumption. The *Emerald* is 236 ft. in length over all, 28 ft. 8 in. in breadth, and 18 ft. 6 in. in moulded depth. She has been constructed under Lloyd's special survey to class 100 A1, and has a fine cut-water stem, with a beautifully carved figurehead, a long square stern, and a range of teak-panelled deck-houses extending amidships for about 118 ft. A promenade deck from side to side of the vessel is carried the whole length of the deck-houses, and on it are placed the boats, and a large teak deck-house for deck lounge and navigating room. The vessel has three sets of steam turbines, three shafts and five manganese bronze propellers—one propeller on the centre shaft and two each on the side shafts. All these have been supplied and fitted on board by the Parsons Marine Steam Turbine Company, Wallsend-on-Tyne. The hull has been specially strengthened to prevent any vibration in the structure from the great speed at which the shafts will revolve. In the engine-room, besides the three turbines and their condensers, and the duplicate electric-lighting machinery, there are a large number of auxiliary engines of all kinds. The main boiler, which is of very large diameter, is fitted with Howden's forced draught.

Shipbuilding in the United States.

There is trouble in the shipbuilding world of America through want of material. The Chief Constructor of the American Navy states that material and skilled workers are not obtainable in sufficient numbers to make satisfactory progress with the shipbuilding orders already given out, and this applies to armour-plating as well. The battleship *Ohio*, building at San Francisco, is twenty-nine months behind her time. The *Missouri*, at the Newport News works, is reported to be twenty months late, and so with other ships, ten months being about the usual time behind for large ships, while torpedo craft range up to forty months. The delay in beginning the *Virginia*, *Pennsylvania*, and *St. Louis* of last year's programme has been taken advantage of to make improvements in detail, a new system for the distribution of ammunition being introduced. In his report, Admiral Bowles records substantial progress in the standardisation of fittings. In America 44 details of fittings have been standardised, and in certain classes of ships standard systems of ventilation and drainage have been arranged. The construction department of the United States Navy have arranged to regulate education in naval architecture, and to offer opportunities for students gaining practical experience. The Commissioner of Navigation for the United States reports that during September there were "officially numbered" as built in the United States 123 vessels of 43,743 tons, as compared with 119 of 31,469 tons, in the previous month. Of these 114 of 9,319 tons were constructed of wood, and 9 of 34,424 tons of steel; 70, of 12,708 tons, were sailing vessels, and 53, of 31,035 tons, steamers. The bulk of the tonnage—not less than 34,530—was contributed by Atlantic and Gulf ports, the Great Lakes ranking second with 7,325 tons. The biggest vessels in the record are Cramp's Red Star Liner *Finland*, of 12,760 tons gross, and the Hawaiian SS. Company's *Texan*, of 8,633 tons, built at Camden. The most notable ship in the list is the schooner *Thomas W. Lawson*, of 5,218 tons gross, which has been built at Quincy, Mass. The aggregate for the three months is 103,421 tons, as compared with 68,395 tons in the corresponding period of last year.

New United States Battleship.

Special interest attaches to the tenders submitted by United States firms for the building of a 16,000-ton battleship for the American Navy, as the private firms are to be now compared with the Government establishments. The New York Navy Yard is the first American Government establishment now awarded a contract for a new warship. Five private firms tendered for the building of the 16,000-ton battleship. The Newport News Company, which has got the contract, asked £798,000, and promised delivery in 41 months; the New York Company £808,000, and stipulated 40 months; the Fall River Company, of Quincy (Mass.) £817,400, and 42 months; the Cramp Company £822,800, and 42 months; and the Union Iron Works, of San Francisco, £830,000, and 42 months. These prices are all higher than for corresponding work in this country. As to the time required for construction, the new battleships of the King Edward VII. class will be delivered in from 33 to 36 months from the date of the contract. In the case of the new United States contract ship the *Louisiana*, it is intended on the part of the Navy Department to take careful records of actual costs so as to compare them with the cost of building the sister ship, *Connecticut*, in the Government yard. The penalty for late delivery is £60 per day for the first month and £120 per day after the lapse of the month. The speed is to be eighteen knots for four consecutive hours, and the penalty for shortness in speed is £10,000 for the first ¼ knot deficiency and £20,000 for the second ¼ knot, after which it will be at the discretion of the Secretary of the Navy to accept or reject the ship.

The "Scotia."

An interesting vessel has left the Clyde on a remarkable voyage, viz., the *Scotia*, which the Scottish National Antarctic Expedition have despatched to explore the South Polar region. The *Scotia* set sail under the leadership of Mr. Wm. S. Bruce. The ship was formerly a Norwegian whaler named the *Hekla*, but during the past seven or eight months she has been so thoroughly overhauled on the Clyde that she is practically a new vessel. She is now a barque-rigged auxiliary screw-steamer of about 400 tons, measuring 140 ft. by 29 ft., and drawing about 15 ft. of water. With her new engines and boiler she averaged a speed of over eight knots at her trial trip. In spite of her immense strength the *Scotia*, whose wooden walls amidships are no less than 25 in. thick, is a well-modelled craft, with fine lines to meet the ice, backed by nine feet of solid timber. The leader, the captain, and the scientific staff are accommodated in an after-deckhouse, the officers in a comfortable cabin amidships, whilst the crew are quartered in the forecastle. The scientific work will be carried on in a deckhouse amidships, the after-part of which forms the galley. Here there is good light for those who have to undertake delicate work, such as with the microscope, hydrometer, and other finely graduated instruments. A second laboratory, mainly for zoology, lies almost immediately below the upper one, between decks, and is reached directly from the upper laboratory. Adjacent to this is a compact and completely-fitted dark-room for photography. Between decks there are two great drums, each containing 6,000 fathoms of cable. The cable is led up on deck to a specially constructed 40 horse-power steam winch, thence over the side of the ship by means of a derrick, for the purpose of trawling and trapping in the greatest depths. The roof of the scientific deck-house and its extension in the shape of a bridge form a centre of activity for the scientists, as this is where all the operations connected with sounding and physical investigation of the ocean will be conducted. The *Scotia* is navigated by Captain Thomas Robertson, of Peterhead, who has had twenty years' experience in Arctic seas, and who has also made a voyage to the Antarctic. The scientific staff consists of half-a-dozen picked scientists, four senior, and two junior. The *Scotia* makes first for the Falkland Islands, where she will coal up before plunging into the Polar area.

Electric v. Steam Winding.

Steam-driven winding engines are notoriously and inevitably extravagant in thêir steam demands. Hence it is that any really efficient and economical substitute would be heartily welcomed, and would give rise to considerable excitement in mining circles. This is, therefore, a reason why just now so many mining men are looking about for the electrical winding engine, and why so much has been mooted of late about electricity applied to winding, and why generally so many inquiries are being made in reference to this matter. For were there not electrical winding plants exhibited at Düsseldorf? And, what is more, plants like those exhibited, or, anyway, like some of them, are actually being installed in some large collieries in Germany. The idea is to generate electricity in a central station where steam may be used with triple-expansion, condensation, and even super-heating, and to utilise the electricity for winding as well as other purposes. The central power station is at once the feature and the pride of many a German colliery, and, in fact, is certain to astonish any visitor from this country by its magnitude and the exuberance of the equipment.

2,800 h.p. for electric winding.

The largest electrically-driven winding engine, and a conspicuous exhibit in the great machinery hall, but destined for shaft Zollern II. of the Gelsenkirchner Mining Company, has a maximum capacity of 2,800 h.p. The electrical portions consist of two direct current motors for 500 volt current, which are mounted on the same shaft as the winding drum or pulley, and a buffer battery of accumulators numbering 216 elements, each containing nine pairs of plates, which not only serves to ensure a good supply of power, but also serves to regulate the speed, inasmuch as the elements are arranged in groups, which can be brought into, or withdrawn from operations as desired. A few elements are also set apart to serve for smaller operations, such as changing tubs, etc.

Speeds Attainable.

By these means the speed can be increased or decreased in stages, such as 6½, 13, 16½, 19½, 26-33 feet per second, which is the maximum speed to be adopted in ordinary practice to begin with; but the presence of the two motors enables a still greater speed to be attained, for, by coupling them up in parallel the ordinary maximum can be doubled, giving increments to 39¼, 52½-65½ ft. per second. Another advantage of having two motors is that operations can go on with one in case the other is deranged, for even with a diminished output it is better than stopping altogether. Of course, there are indicators and various safety appliances, whilst the manipulation of the switches is effected by the moving backwards and forwards of a lever, as in the usual course of events. The switching arrangements being installed under the engine-room floor. The Koepe system, with a drum $19\frac{1}{2}$ ft. in diameter is adopted.

Work to be Done.

The work to be done ultimately is to wind six tubs, each holding $13\frac{3}{4}$ cwt., that is together 4 tons $2\frac{1}{2}$ cwt., from a depth of 1,640 ft. at a maximum speed of $65\frac{1}{2}$ ft. a second in the quickest part of the wind.

Winding with Three-phase Current.

The second large electrically operated winding engine was only shown in a drawing in the Düsseldorf Exhibition, as it was being erected at Colliery Preussen II. of the Harpener Mining Company, and was to be finished about this time. In this instance a three-phase current is used with the motor again mounted on the same shaft as the drum. The current is supplied to the fixed portion of the dynamo at a voltage of 2,000, and is obtained from a central station, in which there are three three-phase generators each of a capacity of 550 kilowatts when running 94 revolutions a minute. They are run in parallel, and also provide current for pumping and other purposes. They are driven by an 800 h.p. twin-coupled horizontal engine.

Speed Regulation.

The regulation of the speed is effected by a liquid resistance. A continuous flow of soda solution is maintained in a vessel in which are suspended the electrodes. The bottom of the vessel can be closed by a valve ; the liquid then rises in the vessel, and as it rises the resistance is diminished and the speed increased, or *vice versâ*. The valve is operated by the chief working lever. The variation of speed depends upon the duty of the circulation pump, and is independent of the engine-man. Koepe is here again the system employed, and the drum or pulley is in this instance also $19\frac{1}{2}$ ft. in diameter, and the work to be done is to wind 100 tons of coal an hour from a depth of 2,297 ft.

The Load.

The factors in the load are four waggon loads of coal, each of $10\frac{3}{4}$ cwts., together just over 2 tons ; tare of each waggon $6\frac{3}{4}$ cwts., together 27 cwts. ; cage and accessories over $3\frac{3}{4}$ tons ; about 2,395 ft. of $1\frac{7}{8}$ inch rope, $4\frac{5}{8}$ tons ; total load about 12 tons. Speed, $52\frac{1}{2}$ ft. a second.

There are Doubts

This installation is really being put in tentatively. The electrical folks have full confidence, but the mining men are not quite so confident ; consequently the latter, when providing the building for the winding machine, built it sufficiently large to accommodate one of those fine majestic steam winding engines that attracted so much attention at Düsseldorf. The effect is very strange, the electrical plant looks such a diminutive apparatus in the big hall intended for its colossal rival.

Friction Pulleys and Electric Winding.

The third striking electrical winding engine produced in Germany has three friction pulleys in one plane, each a little over 8 ft. in diameter, around which a flat rope winds, passing under the outer pulleys and over the middle pulley, which is placed above the other two and is directly driven by two motors mounted on the same shaft ; the lower pulleys are driven indirectly, the tension of the rope pressing them against the driving pulley. Direct current is used at 500 volts, and with 115 revolutions per minute the engine can develop 200 horse-power. The starting and regulation of speed is effected by an independent engine. The engine can wind $13\frac{3}{4}$ cwt. from 1,312 ft.

Modern Steam Winding Engine.

It is interesting to compare with these a steam winding engine of a recent type such as was also shown at the Düsseldorf Exhibition, and an example of which could be seen working at a pit in the Westphalian coal-field. The one exhibited is intended for the second shaft of the same pit of the Harpener Mining Company—that is, Preussen II., where the three-phase electric plant already referred to is now installed. This winding engine is on the Thomson system, with two spiral drums on separate shafts, which are driven by an inverted vertical compound engine, of which the principal dimensions are as follow: Diameter of high-pressure cylinder, 32·3 in.; low-pressure, 45·2 in.; stroke of piston, 102·3 in. The steam pressure is to be 180 lbs. The drums are each 18 ft. diameter at the smaller end, 33 ft. at the larger end, and 11½ ft. in width. The total weight of the engine is 470 metric tons.

Duty.

The engine is to wind from three depths—these are 2,625 ft., 3,281 ft., and 3,937 ft. respectively, and the useful loads to be drawn from each depth are 8 tubs of coal when working from the shallower depth, 6 tubs from the intermediate, and 4 tubs from the maximum depth. Each tub of coal weighs 11 cwt., so the loads will be 88, 66, or 44 cwts., according to circumstances. The maximum speed will be 72 ft. a second, and the mean speed 33 to 40 ft. a second. It was very impressive to see the contrast between these rival engines intended for similar work. But electric winding can only be regarded as barely incepted; what may we not expect?

Electricity in the Salt Mine.

The salt mines of Aussee, in Austria, furnish an excellent example of the successful application of electricity in mining. Power is obtained from a head of water with a 430 ft. fall, which works a high-pressure vertical turbine at 1,100 revolutions per minute, this in turn running a direct-current dynamo also at 1,100 revolutions. The power transmitted into the mine is used for haulage, drilling and ventilation. This haulage is effected by a two-axled mining locomotive worked by a (three horse power) direct current dynamo. The locomotive makes eight journeys in a shift of eight hours, travelling each time one mile and drawing three tubs each with 6 cwt. load; so that 144 cwt. of salt are delivered by it during the shift. The division of time is precisely allotted. Of the 480 minutes of the shift, 40 minutes are allowed for going to work and leaving work, and 30 minutes for resting, 90 minutes for cleaning, lubricating, testing breaks, etc., leaving 410 minutes actual working time. The current also works rotary drilling machines, two of 2 h.p. and one of 3 h.p.

Mining Students Strike for More Work.

A strange strike is announced from Leoben Mining Academy, in Austria. The students have become so numerous that the accommodation has become inadequate and lectures have been interrupted, and even discontinued, owing to overcrowding. To this the students took exception, and went on strike, demanding adequate accommodation, and a proper number of lectures. They elected representatives to confer with the authorities and the district council, and even the Government head officials have been approached, and the matter will receive attention. But the students have been warned that discipline must be maintained, and that further breach might lead to the closing of the academy for the season. So peace reigns again in this romantic corner of the Austrian Empire.

NOTABLE BRITISH PAPERS OF THE MONTH.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of Great Britain.

SIR WILLIAM PREECE ON RAILWAYS AND TELEGRAPHS.

At the first ordinary meeting of the Society of Arts, held on Wednesday, November 19th, the chairman, Sir William H. Preece, K.C.B., F.R.S., gave an interesting address in which he dealt with the causes which result in successful or disastrous financial undertakings, and endeavoured to show that the commercial conduct of industrial processes arising from the practical applications of discoveries, follow distinct laws, which may be said to constitute a "science of business." After discussing the principles which govern the establishment of public companies, Sir William Preece proceeded to survey, from a broad and general point of view, the progress of certain industries in which he has had more or less personal experience, dealing first with the supply of gas and water.

RAILWAYS.

The curves (fig. 1) show that the commercial soundness of the railway interests in the United Kingdom is in anything but a satisfactory condition.

The mileage of railways open is 22,078.
The capital invested is £1,195,564,478.
The revenue is £106,558,815 ; ratio to capital, 8·9 per cent.
The expenditure is £67,489,739 ; ratio to revenue, 63·3 per cent.
The profits are £39,069,976 ; ratio to capital, 3·27 per cent.

There is no apparent allocation of this difference to depreciation, reserve, or redemption of capital. While capital is increasing, and the growth of traffic both in passengers and goods is satisfactory, the rate of growth of revenue is stationary, and the difference between expenditure and revenue is seriously diminishing. The consequence is that dividends are also diminishing. This state of affairs would be very serious if we did not see daylight ahead.

THE ELEMENTS OF FINANCIAL DISTURBANCE.

What are the causes of the present depression ? The first cause is unquestionably Parliament, which legislates for the railway world without the least regard to the science of business or the ordinary requirements of commercial prudence. The enforcement of cheap fares and workmen's trains at the expense of the shareholders is pandering to a sentiment, and savours of a bribe to catch votes.

The operation of the Railway and Canal Traffic Acts of 1888 and 1892 forbids our railways being worked on commercial lines so far as goods and mineral traffic are concerned. What is to be said of a law which places an impediment in the way of reducing rates by enacting that they may not be restored, if their reduction be found not to have led to the expected result, without liability to an expensive law suit ? Or to the refusal of permission to restore the rate to its old figure without such elaborate proof of change of circumstances as shall satisfy the Railway Commissioners that it is right to do so ? Other industries could not live if exposed to such conditions, and their effect is most detrimental to our railways.

The Board of Trade is ceaseless in its

application of new regulations. The result of the control of this Department has been most beneficial to the safety of the travelling public. The lives saved annually are untold. We have every reason to be proud of the security of our lines. But the finances of our railway companies have been sadly dislocated by this enforced incessant expenditure, and our managers are much exercised to determine what to charge to capital, and what against annual revenue.

LOCAL TAXATION.

The local authorities and municipalities also are insatiable in their unscrupulous assessment for local taxation. The growth of this drain on the resources of the companies is [illegible] The taxation of railways has in- [illegible] per cent. in the last decade, while [illegible] the whole community has increased [illegible] per cent.

[illegible] unionism has generated a serious [illegible] trouble. Shorter hours, greater pay, and [illegible] staff are very desirable for the men [illegible], but these advantages are not to be [illegible] if they lead to financial deadlock and [illegible] disregard of the dictates of commercial [illegible]. The men cannot obey two masters, nor [illegible] must masters submit to the external [illegible] of their business by self-constituted second masters. If this were submitted to, chaos and bankruptcy would be the result.

THE COMPETITION OF ELECTRIC TRAMWAYS.

The railways are now subject to a very serious competition in the introduction of electric tramways in their suburban districts. The American railway companies have recognised this, and they have not only electrified their suburban lines but they have developed a tramway system themselves to act as feeder to their own system, and to enable them to close stations and transfer passenger traffic to street tramways.

Automobiles will also certainly interfere with passenger traffic.

RAILWAY COMPETITION.

But the most serious element of financial disturbance is competition among the great railway companies themselves. The demand for increased speed and greater comfort has led to new stations, big hotels, larger locomotives, superior coaches of greater capacity, heavier rails, straightened curves, revised gradients, and reduced distances. Capital has been increased without the productive increase of traffic or earning power, for the expenditure is caused chiefly by the necessity to hold one's own.

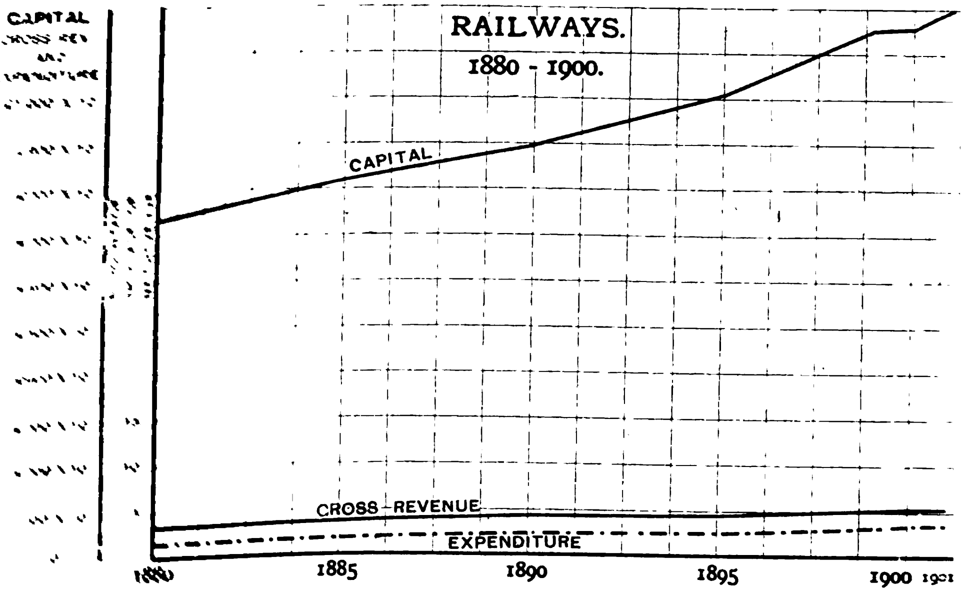

FIG. I.

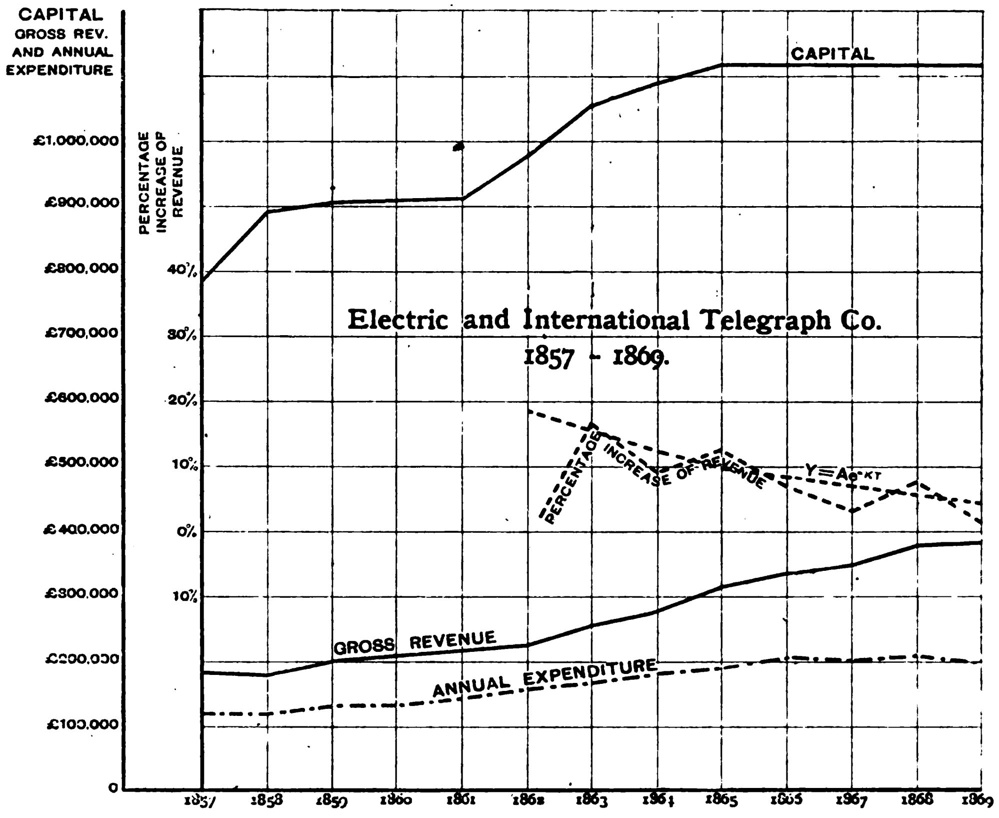

FIG. 2.

THE REMEDY.

Now, what is the remedy? I am no believer in the conception that electricity is to be the panacea for every evil. There is little sign at present of our being able to work main lines economically by electric traction. When, however, a line worked by steam is congested, and you can get no more trains through, as it is on our Metropolitan underground lines, and as it is on many suburban lines, then electric traction comes in to increase the speed of running, to enlarge the carrying capacity of the line, and to reduce the working expenses.

The true remedy is co-operation and combination among the great railway companies themselves, and if the railway companies do not realise this fact, and set to work to put their houses in order, they will find that the last and least desirable, but most effective measure will be enforced upon them by public opinion—the financial control of the railways by the State.

TELEGRAPHS.

Fig. 2 is a diagram of the business of the Electric and International Telegraph Company from the year 1857 to its transference to the Government. It shows steady progress and financial prosperity, following the logarithmic curve. The Government made a good bargain in its purchase; it is the fashion to depreciate this purchase. Indeed it is the inalienable right of virtually half the British race to decry the action of the other half. Facts have no effect on party bias. The £5,715,000 paid by the Government for the telegraphs are now worth £30,000,000, and no one believes it!

Fig. 3 shows the growth of this General Post Office business. It also obeys the logarithmic law. There is no capital. Everything is charged to revenue. The working expenses are apparently very high, but if they were taken as they should be, at a fair commercial figure, say 57½ per cent., the profit would be considerable.

TELEPHONES.

The telephone business of this country defies diagramatic analysis. It has had a curse upon it from its first introduction. It is now in a state of chaotic confusion. It has been the shuttlecock of politicians, and the football of local authorities. The attempt to force it on the municipalities is likely to prove a failure. Tunbridge Wells has lamentably broken down. It is an imperial business, a part and parcel of the business of the Post Office, and the only possible solution of the present deadlock is for the Government to cut the Gordian knot and take over the business in 1911.

DEDUCTIONS.

In all well conducted businesses profit is usually distributed to meet :—

1. *Depreciation*—which is a term applied to the diminution of the value of the plant as a whole, due to time and work acting upon it, and finally causing its complete decay.

2. *Renewals*—which is a term applied to the periodical replacement with new materials of the parts of the plant that wear out most rapidly.

3. *Reserve*—which is a fund invested *outside the business* formed as a species of insurance to be prepared for emergencies, accidents, and fires, and to meet what we call in England *antiquation* of plant, or what they call in the United States *betterment* of plant.

4. *Redemption*—which is the formation of a sinking fund, in the course of time wiping out the capital raised by loan or subscription.

5. *Dividends* and *bonuses*—which are the distribution to shareholders in cash of the surplus of the profit earned.

Sound finance means a proper appreciation of all these points, and a due and proper allocation of a portion of the annual revenue to meet each requirement. Practice is very variable. Different businesses require different treatment.

In electrical industries depreciation and renewals must be continuous, and must be the first charge against revenue. Electric plant must be maintained in absolute perfect order up to the hilt, otherwise it fails to be productive, and rapidly becomes very inefficient. Hence depreciation and renewals are provided for in the ordinary annual maintenance expenditure. Reserve fund is, however, essential in all growing businesses, and the

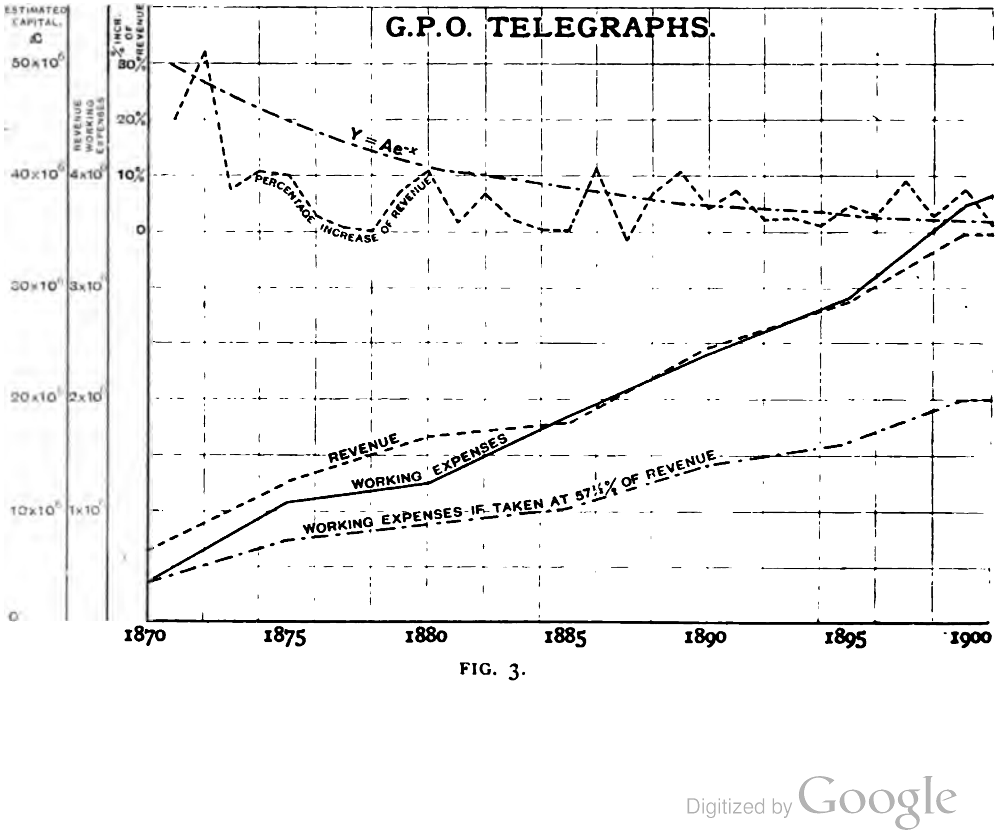

FIG. 3.

soundness of the financial control is shown more by the condition of the reserve fund than by any other monetary sign.

MUNICIPAL UNDERTAKINGS AND THE REDEMPTION OF CAPITAL.

Redemption of capital is a compulsory feature of municipal undertakings, erected with capital borrowed under the authority of the Local Government Board. The rate at which the loan is redeemed is determined by the nature of the work undertaken. The present rule is for—land, 60 years; buildings, 30 years; machinery, 15 years; electric mains, 30 years. No dividends or bonuses are allowed in such municipal industries. The profits are devoted to the amelioration of the rates, but in all businesses established by private enterprise under the Limited Liability Act the surplus profits are distributed as dividends and bonuses.

THE FORMATION OF RESERVE FUNDS.

The formation of a good reserve fund is imperative in all undertakings dependent on moving machinery, for invention is so prolific and improvements so rapid that antiquation is soon reached and betterment needed. It is also necessary in the case of private undertakings established under the Tramways or under the Electric Lighting Acts, for in those cases at stated periods the municipality has the power to take possession of the business at its *then* value of the plant, and no allowance is made for goodwill or compulsory purchase. Sound finance seems to show by experience that 2½ per cent. on the capital is about the average amount that should be allowed annually to form a substantial reserve.

There are risky adventures, like submarine cables, where larger amounts should be put aside. The Eastern Telegraph Company is an admirable instance of sound finance. It has been in existence for thirty years. Its invested general reserve fund amounts to £1,164,673 2s. 2d. Its capital is £10,249,170. Its gross revenue is £1,200,000.

THE NECESSITY FOR UP-TO-DATE MACHINERY.

The value of scrapping is not appreciated in England. In America, when a new process is introduced, which effects considerable economy in production, it can be shown by simple calculation that it is wise and commercial to sweep away the old plant and install the new; and this is done. English manufacturers are most tenacious of old machinery. I have seen old Boulton and Watt machinery at work that absorbed annually an excess of coal and oil costing sufficient money to have justified its removal a generation ago. But it is in the increased rate of production that justification for scrapping comes in.

The American does not wait until a machine is worn out before condemning it. As soon as he realises the fact that up-to-date machinery will save him in time and labour enough to justify new plant, away goes the old plant, and the value of the new is soon repaid by greater production. In the majority of cases the "betterment" of machinery is charged against revenue, but it is easy to justify its charge against capital if the value of the increased production exceeds the interest on the sum of the capital invested in the old and in the new plant. However, the judicious manufacturer should be fortified with a reserve fund to provide against antiquation and provide for betterment.

CO-OPERATION AND COMBINATION.

There seems something radically wrong, from a scientific point of view, in some of these gigantic "combines" that have originated in the U.S.A. It is startling to find that each holder of £1,000 in the White Star Line will receive £14,265 for his share from the new Atlantic Shipping Combine. Upon what capital is profit to be distributed which will enable the new holder of £14,265 to be as happy as the late holder of £1,000? Whence are the new profits to come?

It is not even clear where the money is to come from (or the traffic to pay that money) to gain any profit whatever on the millions projected to permeate the soil of London with "tubes."

On the other hand, combinations and co-operative societies, associated with a judicious system of management, must offer considerable economic advantages in encouraging production, maintaining fair prices, securing good markets, and adjusting a margin between expenditure and revenue which will satisfy buyer and seller.

The key of commercial success is the discovery or construction of a new market, aided by a cheap and reliable mode of distribution. The parcel post is the most efficient means at our disposal to distribute the products of home industries throughout the United Kingdom. Every town and every house thus becomes a new market. We have to educate heads of families in these facts; and this can be done by societies and local industrial exhibitions. Advertising is now a science.

WANTED—A BETTER CONSULAR SERVICE.

The crying demand of our countrymen abroad is for representatives who will make the interests of the British merchant their own. What the merchant wants, to secure him an equal chance for business with the rest of the world, is broad-minded and energetic Consuls, and from the facts I have detailed above, it would seem as if there existed sound cause for recommending a great deal of the American method in the constitution and working of a new commercial Consular service, whose motto should be, "English Trade and Commerce, First, Last, and all the Time."

The Germans have an admirable Intelligence Department all over the world. If any electric development is foreshadowed or suggested in any one of our colonies, especially those in which my firm acts as consulting engineer, we at once receive intimation of the fact from Germany and often from America. We never once have received similar information from any British source!

THE EFFECT OF SEGREGATION ON THE STRENGTH OF STEEL RAILS.

At a meeting of the Society of Engineers, held at the Royal United Service Institution, Whitehall, on November 3rd, a paper was read on the above subject by Mr. Thomas Andrews, F.R.S., M.Inst.C.E., F.C.S.

The author observed that in the course of his wide experience as consulting analytical chemist and metallurgical testing engineer to several English railway companies, he had had exceptional opportunities of studying some of the sources of weakness leading to the fracture of steel rails. In order to more fully investigate on a large scale some of the causes of the loss of strength in such rails, he undertook a careful research on the effect of segregation on the strength of steel rails.

Some idea of the magnitude of the experiments will be obtained when it is stated that they have taken nearly seven years to carry out, and that in the course of research complete chemical analyses, physical tests and high power microscopic examinations have been made on a very considerable number of steel rails, the samples experimented upon having been selected from large bulks of rails as supplied to various railway companies.

The general results of the research have shown the importance, in the interests of the public safety, of railway companies having careful chemical, physical, and microscopic tests regularly made on rails, selected from the bulk after delivery to the railway companies, prior to their going into main line service, so that a tendency to a locally segregated chemical composition may be detected and avoided. Much may be done in avoiding a segregated condition in rails by having them made in accordance with the author's chemical and physical specification and tests.

REVIEW OF LEADING CONTINENTAL PAPERS.

A Monthly Review of the leading papers read before the various Engineering Technical Institutions of the Continent.

ELECTRO-MAGNETIC ORE PREPARATION.

"A NOTEWORTHY feature at the Düsseldorf Exhibition were the plans, shown by the Maschinenbau-Anstalt Humboldt, of the electro-magnetic ore preparation plant for the San Fix tin mines, Spain," remarks Engineer Fr. Frölich, of Berlin, in a paper to the *Verein Deutscher Ingenieure.*

The ore from the washery is first dried in a hot coil, the steam given off being drawn away by a fan. By means of a bucket-chain the coil delivers the dried ore into a *Siebtrommel*, or screening drum, with 3-millimetre (barely ⅛ in.) holes, what does not pass through being crushed between rollers and again brought up to the screen. The ore that passes through is then separated in another screening drum into grains of three sizes, each being further treated independently. The separators are electro-magnets, through whose magnetic field the ore is led by a band travelling on rollers; and these magnets are in each case arranged three together, one behind the other. The separated particles are taken off by cross bands that are brought up under the magnet poles, while what remains, which is less magnetic, is dealt with a second time by more powerful magnets.

The plant, which has been in operation with good results since the beginning of the present year, is so compact that it occupies but little ground space.

LIGHT, HEAT AND POWER FROM ALCOHOL.

THE international competition of motors and other appliances utilising methylated alcohol for industrial purposes, lately held in Paris, formed the subject of two communications to the *Société des Ingénieurs Civils de France*, one by M. G. Coupan on motors, and the other by M. G. Arachequesne on

LIGHTING AND HEATING.

The recent exhibition, he observes, was a decided triumph for appliances using debased spirit for producing heat and light; and the main question as to the possibility of lighting by alcohol is now settled, leaving only the best solutions of that problem to be discussed from the standpoints of safety and economy. The degree of safety against fire and explosion has been greatly increased; and it is not too much to say that at present alcohol appliances entail less danger from explosion than do those burning gas or petroleum spirit, while the alcohol flame is more easily extinguished (by water, generally at hand), than is that of rock-oil.

Whether for lighting or heating, the alcohol must be burnt, which is an easy matter; but the combustion is due to two different principles (1) direct ignition of the liquid spirit, and (2) ignition of the spirit previously vaporised. Appliances depending upon the first of these principles may be again divided into those with (*a*) open vessels, in which the spirit is ignited directly; (*b*) closed vessels in which it is ignited at the end of a cotton wick; and (*c*) vessels in which it is ignited after having been previously absorbed by a porous substance.

Appliances burning alcohol previously vaporised are practically gas-works, in which the retort and pipes are replaced by a small boiler where the spirit is turned into gas; but what distinguishes one from another is the method of feeding, whether by wick or pressure, and especially the mode of heating. Indeed, it is the mode of heating which permits of sub-dividing these appliances into four classes, according as the spirit is vaporised by (*d*) a permanent pilot-flame ; (*e*) a shunt, or subsidiary flame ; (*f*) its own flame ; or (*g*) regeneration by conduction.

Conformably with theory, heating and lighting appliances that burn carburised alcohol are more economical than those utilising the spirit simply debased, which should be preferred for domestic purposes owing to its high degree of safety, whereas the former is to be recommended for use under pressure, for intensive public lighting, and for automobiles, especially in cold climates.

MOTIVE POWER.

Trials of explosion motors soon showed (observed M. Coupan) that the volume of air incorporated with the combustible substance exerts a marked influence on the motor's economical working, and that the utilisation of the combustible is at its maximum when the proportion of air in the explosive mixture is appreciably greater than that given by calculation according to the chemical reaction. So long, however, as gas, petroleum, shale, etc., were the only combustible substances practically employed for explosion motors, no attempt was made to exactly determine the proportions in which the substances should enter into the explosive mixture for ensuring complete utilisation ; but, directly attempts were made to substitute alcohol for raw or rectified petroleum, it became necessary to study the phenomena characterising its combustion, because unexpected difficulties were encountered, such as the fouling, setting fast, and even corrosion of the valves.

It appears from the united investigations of M. Sorel and M. Ringelmann that the combustion of alcohol can never be absolutely complete, however perfect, as regards the proportion of combustible and supporter of combustion, by the composition of the explosive mixture, appreciable traces of acetic acid being always found in the exhaust products. This is, however, but a minor difficulty, as the consequent loss of alcohol is very slight ; and this acid does not appear to corrode the parts of the motor, at any rate while working, while lubricating the cylinder after each stoppage is sufficient to prevent the corrosion due to prolonged contact between the metal parts and the condensed products containing acetic acid.

Analyses of the exhaust gases have shown that, without the proper proportion of air, part of the hydrogen, and especially of the carbon, contained in carburised or uncarburised alcohol is entirely unutilised, the loss being specially high in light fast-running engines. In heavy motors the combustion was, in most cases, found to be practically perfect when the proportion of air in the explosive mixture was 1·7 times that theoretically necessary ; but above and below this proportion the combustion was imperfect, the degree of utilisation becoming more and more defective as the theoretical proportion was approached. Accordingly, whatever be the mode of regulating the motor, the carburiser should be capable of sending into the cylinder a quantity of alcohol corresponding with the best degree of carburisation, determined in accordance with the cylinder's capacity, account being also taken of the excess of air normally required for the combustion.

The carburiser preferred by the author is one which automatically injects the requisite quantity of alcohol, *in a liquid state*, into a chamber where the volatilisation and mingling with air are effected ; and the organ for injection, or, more correctly, mechanical distribution, should be susceptible of regulation, so as to permit of determining empirically the exact quantity of alcohol necesssary for each explosion, while leaving every latitude for use in the motor of various kinds of combustible substances. Provided well-designed carburisers and vaporisers be employed, M. Coupan concludes that alcohol may be regarded as a good agent for producing mechanical energy.

DETERMINATION OF A COAL'S HEATING POWER.

CALORIMETRIC determinations by the Mahler shell have often shown great divergence between actual calorific powers and those found by calculation with the aid of formulæ proposed up to the present time, all of which have been successively abandoned by M. Goutal (whose note on the subject was brought before the *Paris Academy of Science* by M. Adolphe Carnot) on account of their inaccuracy or their being based on delicate and complicated determinations. Inasmuch, however, as the ascertaining of a coal's calorific value by simple calculation appeared to possess a certain industrial interest, the author endeavoured to establish a relation between this calorific value and the results afforded by actual testing—*i.e.*, by calcination, incineration and dessication—for determining the fixed carbon, the volatile matter and the humidity.

After having experimented with 600 samples of coal from various sources, M. Goutal became convinced that the results may be expressed with near approximation by the formula—

$$P = 82\,C + aV,$$

in which P is the calorific value sought,[*] C the proportion in hundredth parts of fixed carbon, V that of the volatile matter, and *a* a variable multiplier, function of the volatile matter content; V', free from ash and water, while

$$V' = 100\frac{V}{C+V}$$

For experimentally determining the value of *a* for various fuels, the author constructed a graphic diagram from the results of his numerous tests, taking the volatile matter contents, V', for the abscissæ, and the corresponding values of *a*, deduced from the calorimetric combustions, for the ordinates, this co-efficient assuming, for volatile matter contents of 5, 10, 15. 20, 25, 30, 35, and 40, the respective values of 145, 130, 117, 109, 103, 98, 94, 85, and 80 calories.[*] For the anthracites *a* is represented by a constant equal to 100 calories, the formula becoming

$$P = 82\,C + 100\,V.$$

In thus calculating the calorific power of a coal, the error rarely exceeds 1 per cent. of the real value; but, as an exception, it is greater than 2 per cent. in the case of some anthracites and some lignitous coals, the value of which can only be ascertained by the calorimeter.

The mean calorific power of pure anthracite is 8,250 calories per kilogramme (14,850 B.T.U. per lb.); that of the anthracitous coals, for which V' varies from 5 to 10 per cent., is 8,550 calories per kilogramme (15,390 B.T.U. per lb.); and it attains a maximum, 8,700 calories per kilogramme (15,660 B.T.U. per lb.), in the case of coals for which V' is comprised between 10 and 30 per cent.

It follows that the calorific value of coals increases in inverse ratio to that of their volatile matters up to the limit content of 30, after which the calorific value of natural fuels and that of their volatile matters decrease together.

ALUMINOTHERMY.

THIS term is given by Dr. Hans Goldschmidt, of Essen-an-der-Ruhr, to a process applicable to the reduction of metals and heating of metal parts, which is founded on exothermic reaction, progressive and practically spontaneous; and the name was chosen because aluminium has been found to be the metal of moderate cost which, owing to its affinity for oxygen or the high degree of heat given out during its combustion, best serves in most cases as the reducing agent in practical applications of the process. According to Herr Strauss' investigations the combustion heat of aluminium is 7,140 calories per kilogramme (12,852 B.T.U. per lb.), coming immediately after hydrogen, 34,200 calories (61,560 B.T.U.), and carbon, 8,317 calories (14,970 B.T.U.), being greater than that of the other metals or metalloids. Aluminium may, however, and must even in some cases, be replaced by another metal, so that the field covered by aluminothermy is more extensive than that implied by the term.

PRINCIPLE OF THE PROCESS.

If with a pulverulent metallic compound—oxide, sulphate, etc.—be intimately mixed a metal in the state of powder whose affinity for oxygen, sulphur, etc., is greater than that of the combined metal, and if the mixture be heated, so soon as the mass attains a certain temperature depending on the nature of the substances, a reaction with disengagement of heat will take place; the oxygenated or sulphated substance will be decomposed, and the metal that was in combination will be set free, while the oxygen or sulphur will combine with the free metal.

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[*] The author of this paper, M. E. Goutal, head of the chemical laboratory at the Paris School of Mines, has kindly explained that, although the calorific power of coals is generally (in France) given in calories per kilogramme, this is not the case for the values of *a* in question. The latter correspond with the results of analyses expressed in hundredth parts—in the present case 1,000 ÷ 100 = 10 grammes ($\frac{1}{3}$ oz.). To render these values comparable with the usual measurements they must therefore be multiplied by 100, giving 14,500, 13,000, 11,700, 10,900, 10,300, 9,800, 9,400 8,500, and 8,000 calories per kilogramme. For obtaining the equivalent British thermal units it is sufficient to multiply these figures by 1·8.

This would appear to be a metallurgical process suitable for extracting metals from their ores without coal; but the reaction is so violent as to throw forward to waste part of the substances, while rapidly destroying the receiver containing the mixture. Dr. Goldschmidt has, however, found that this difficulty ceases if, instead of heating the whole mass, the reaction be merely set going by raising a point in the mass to the desired temperature. With a suitable mixture the heat given out by the local reaction thus produced is sufficient to raise neighbouring parts to the reaction temperature, so that the action of the reducing metal is gradually propagated throughout the mass without any extraneous heat.

APPLICATIONS.

Although this process is of comparatively recent invention, its applications are both numerous and varied; and it has now entered into current practice for welding metal parts, the repair of forged and cast objects, the making of complete spare parts, and the production of metals and alloys free from carbon. By the reaction of aluminium on the oxides this process also produces artificial corundum as a by-product; and Dr. Wolff lately proposed to apply it to the production of calcium carbide without employing the electric current.

PRINCIPAL ADVANTAGES.

1. The metals and alloys produced by this process are free from impurities, especially carbon, since that element does not enter into the reaction mixture. It is also asserted that they are almost free from aluminium, which circumstance is all the more remarkable because that substance is classed among the metals that can most readily be allied to others.

2. The inventor claims that, by employing suitable oxides, the highest possible temperatures may be obtained without cumbrous appliances, while, on the other hand, the sulphates afford the low temperatures that may be required for some applications.

3. It is possible to exactly determine beforehand, and within the widest limits, the heat to be given out by the reaction, its degree only depending on the nature and quantity of the substances present, and also to regulate the temperature obtained, that depends on the heat given out and the mass of matter over which it is distributed.

CONCLUSIONS.

These observations are contained in a communication to the *French Civil Engineers' Society* by M. H. Bertin, who went on to describe in detail the modes of practically applying the process, dealing *inter alia* with the substances to be employed, starting the reaction, casting, preparation of the metals and alloys, autogenous welding and welding with thermit, as also their advantages, and concluding that Dr. Goldschmidt's discovery is probably destined to take an important place in metallurgical practice.

SUPPRESSION OF BELTS FOR DRIVING DYNAMOS, ETC.

WITH an intermediate shaft for driving, the pulleys require frequent attention, while the belts, having indifferent adhesion, slip and sag, so that the efficiency is low; and, in the case of electric lighting, the light is inconstant, with the well-known disadvantages attending this defect. By suppressing the intermediate shaft, however, a constancy of light may be obtained that is otherwise only obtainable by the use of accumulators. Strangely enough, when the motor is a gas engine, the belts are relied upon to compensate for the irregularity of its working; and this compensation—the curing of one evil by another—has been characterised by Professor Witz as "mechanical homœopathy."

A simple and efficient method of driving, observed M. Defays, in a communication to the *Société Industrielle du Nord de la France*, is that devised by M. Denis, of Saint-Quentin, who employs friction pulleys of silicated cardboard, that have the great advantage of doing away with loose pulleys, owing to which belts are apt to slip off; and the success he obtained in driving turbines led him to extend the use of these cardboard pulleys to dynamos, fans, centrifugal pumps, etc. Thanks to the arrangement of carriage on which the driving pulley is mounted, and which is fed up by screw and hand-wheel, both starting and stopping may be effected gradually and without shock.

In the case of a dynamo receiving its motion from a shaft, a cast-iron pulley on the latter is brought into contact with the silicated cardboard pulley on the dynamo shaft, plate springs being interposed to render shock impossible; and with this arrangement the speed can be increased without the use of belts or spur gear.

Hitherto only small powers have been transmitted by this method; but the author is of opinion that, if the lengths of contact be made proportional to the efforts, considerable powers may be transmitted. As a rule, a larger proportion of power is transmitted by friction pulleys than by belts of the same width and speed. M. Denis' dynamo, that was installed with intermediate shaft, had to run at 1,350 revolutions; but when friction pulleys were put in, the speed was reduced by 150 revolutions for the same voltage.

THE CARDBOARD PULLEY DIMENSIONS

are determined by the formula

$$l = 3{\cdot}5\sqrt{\frac{e}{\pi n}},$$

l being the pulley's width, equal to its diameter; e the power to be transmitted, and n the number of revolutions, while the co-efficients were found by trial for powers up to 10 h.p., with speeds of 1,000 to 1,200 revolutions per minute.

APPLICATIONS OF THE METHOD.

An application that at once suggests itself is that to reducing the speed given by steam turbines; and a centrifugal pump may be driven directly with great saving in first cost. At the Paris Exhibition of 1900 some Marinoni printing machines were driven directly at 80 revolutions by a dynamo making 1,200 revolutions per minute; and M. Denis has a fan that has been driven by his method for more than ten years, during which the friction cone has only been renewed once.

For driving a drilling machine at variable speed, friction cones of curved contour are used, one of them being canted so as to obtain contact at such a point as shall give the required speed, while the method is also applied to electric cranes and wood-working machinery.

THE NEW RUSSO-FINNISH ELECTRIC RAILWAY.

THE St. Petersburg *Viedmosti* publishes details of the projected long-distance electric railway between St. Petersburg and the Fall of Imatra, in Finland. A concession has been granted for the building of an electric railway to the Finno-Russian frontier, but the Finnish Senate is now considering the petition of Mr. A. L. Von Knorring to continue this line for a total distance of 165 kilometres to Imatra. For the first 20 versts, to the village of Yokka, the line will be double, the remainder of the distance having a single line. The limit of speed is put at 78 kilometres an hour, or an average of 60 kilometres, including stoppages. This will enable the distance from St. Petersburg to Imatra to be covered in 2¾ hours. The local traffic between St. Petersburg and Yokka will be carried on in separate four-wheeled carriages, each equipped with an independent motor, and carrying thirty persons, while the long distance traffic will be carried on in eight-wheeled carriages, holding fifty persons each. On the shorter journey a carriage will be despatched every five minutes, and to Imatra one every hour. The goods traffic will be transported in similar separate waggons, but will be despatched only during the night. The estimated cost of the railway is put at 10,000,000 marks.

BOOKS OF THE MONTH.

[illegible] will be paid to all books dealing entirely or in part with subjects [illegible] While space will be given for expressions of opinion on books or [illegible] be submitted for that purpose, contributors will please remember [illegible] the main for reviews of technical books dealing with the Engineering, [illegible] Iron and Steel, Mining, and Allied Industries. The address of the publisher and [illegible] prices should be enclosed in all publications sent for review.

[illegible] TRUSTS AND THE TARIFF

[illegible] Macmillan and Co.

[illegible] succeeded in gathering together in the form of a readable volume [illegible] concerning the present day [illegible] the operation of the American tariff. [illegible] has been made to present the most [illegible] of the question in form suitable [illegible] every day reader. Mr. Bolen [illegible] with a brief sketch of the origin [illegible] trusts, and after discussing their [illegible] for good and evil, he proceeds to describe the working of the various [illegible] with special reference to railways [illegible] trading. Concerning the railroad [illegible] he says:—

[illegible] perfect in every respect, needing [illegible] the agitation against [illegible] not in [illegible] It is in [illegible] charges [illegible] company, [illegible] pulling down [illegible] to furnish [illegible] along the way. [illegible] built up [illegible] Railroad [illegible] the forces of [illegible]

Government ownership is not regarded as the remedy, as the author thinks it would involve lower efficiency, slower improvement, and perhaps higher cost. He, therefore, advocates a continuation of the policy of regulating railway traffic by law. In another chapter we have further facts concerning the evils of railroad competition. An antidote to the rate-cutting which is carried to such a ruinous extent in the States, the writer is inclined to favour the system of permitting the formation of railway "pools," supervised by the Inter-State Commerce Commission, and subject to their approval.

> By this arrangement, rates and regulations could be kept reasonable to the public by the Commission, *and* every company could be held by the others to the pool contract by law. Instead of separate agencies, each lowering rates to get the business of large shippers, one joint office would answer for all the roads.

In conclusion, the author speculates as to the ultimate influence of the Trust *régime* on the public. There is no reason, he thinks, why capitalistic production, under public control of monopoly, should not continue to give society the best, cheapest and most rapidly improving supplies; but he speaks out strongly against selfish and uncontrolled monopolies. On the other hand, he says, the trusts that are wanted are those that hold their position solely by reason of surpassing excellence and cheapness of product.

> These trusts are only too few, if they exist at all. But the club-wielding monopoly trusts, formed to squeeze customers, will discover that the people are not so helpless as they seem. Their power to restore just conditions will appear when they comprehend clearly what the monopoly trusts have undertaken to do. From the survey in these chapters of the trust situation, it does not seem that radical action will be necessary to dispose of them. Managers of trusts will realise quickly, perhaps with voluntary obedience to the public will, that now and hereafter, as always heretofore, private property and capitalistic production, to continue to exist unimpared, must prove to be the best system by service to society. Limiting the capital of corporations, and the kinds of business in which they may engage, as some economists have proposed, will apparently be postponed until the trust proves how far honest methods will maintain a monopoly.

In the second part of the book Mr. Bolen sketches the arguments for and against Protection, and adduces many facts in support of both theories. On the whole, the author may be said to have dealt with the subject in a fair and unbiassed manner, the work showing many evidences of keen insight and a conscientious study of the problems at issue.

"BRITAIN AT WORK."

A Pictorial Description of our National Industries. Cassell and Co. 4to. 384 pp. 12s.

IN this handsome volume the publishers have thrown open the doors of our national workshops and revealed to the reader the wonders of the nation's industrial life. In the course of fifty-nine fascinating articles, written in a popular style, we pass in review the battalions of Britain's workers, and visit the primary sources of her wealth and prosperity. Almost every variety of art and craft is described, and nearly every occupation portrayed, from the making of matches to the construction of an ironclad. The writers of the various articles have been assisted in their task by the photographer, who has supplied them with over 500 illustrations, finely reproduced by half-tone engraving.

Perhaps the most interesting sections are those devoted to the engineering and allied trades. The first of these, by Mr. H. W. Wilson, describes the building of a battleship, and we are able to watch its progress from the time of its laying down until it leaves the slip. A brief survey is given of the various yards and their specialities, including illustrations showing war vessels under construction in the yards of Sir W. G. Armstrong, Whitworth and Co., and the Thames Ironworks and Shipbuilding Company, Ltd. Another writer tells of Britain's underground wealth—of the collier's work in the mines and the transport of the fuel to the workshop and the fireside. The reader is then shown the processes involved in the production of iron and steel, illustrated by photographs taken in the Atlas Steel Works, the Yorkshire Steel and Iron Works, and the Cyclops Steel Works at Sheffield, and others. Further on we make the acquaintance of railway enginemen and their work, and get a glimpse of electric tramway systems, work in the great docks of London, Liverpool, and Southampton, needle and pin making in the Midlands, and the labours of the women nail and chain makers of the Black Country. Mr. R. W. Johnson contributes an article on the making of big guns, illustrated by photos of machinery in the works of Messrs. Vickers, Sons and Maxim, Sir W. G. Armstrong, Whitworth and Co., and Messrs. Cammell and Sons, of Sheffield. Mr. John Pendleton, who is responsible for several of the above-mentioned articles, also writes on the engineering industry generally, but he is obviously hampered by the limitations of space. There are illustrations of the Manchester Ship Canal, of bridges and cranes (by Messrs. Whitaker Bros., Ltd., of Leeds), the new floating dock at Bermuda, built by Messrs. Swan and Hunter, Ltd., and views in the works of Messrs. Mather and Platt, Ltd.

The book, which is a splendid example of the printers' art, is one of rare interest. It will be perused with pleasure by the technical reader, and its pages will convey to the general public a vivid impression of the sources of Britain's commercial greatness.

"AN OUTLINE OF THE METALLURGY OF IRON AND STEEL."

By A. Humboldt Sexton. Scientific Publishing Company, Manchester. 620 pp. 16s. net.

MR. SEXTON has set himself the task of gathering together in one work all the chief data connected with the metallurgy of iron and steel, and has succeeded in outlining practically the whole field of theory and practice. The chapters on blast furnace work are especially instructive, indicating much research. A full description of the Bessemer and Siemens process is given, and a chapter devoted to special steels. The section anent the structure of iron and steel is of great interest, and includes some hitherto unpublished facts. The book is well illustrated, has an ample index, and a glossary of metallurgical terms. Much new and valuable information has been utilised, and the work forms a useful addition to the list of modern industrial text books.

A number of reviews are unavoidably held over this month owing to pressure upon ou space.

NOTES AND NEWS.

The Korting Gas Engines.

By way of a supplement to the announcement in our October issue that Messrs. Fraser and Chalmers had secured the manufacturing rights for Körting Gas Engines used in connection with the steel industry, it should be mentioned that Messrs. Mather and Platt, Ltd., have secured the right of manufacturing these large gas engines for all other purposes outside the industry named.

This engine is of the double-acting two-cycle type, that is to say, each side of the piston receives an impulse at every revolution in contradistinction to the single-acting "Otto" cycle engine, which receives an impulse on one side of the piston only once in two revolutions.

The firm is taking up the manufacture of gas engines of large power more especially for driving dynamos, and as they also construct the latter, they are able to build the complete combined plant in their own workshops.

The Junior Engineers.

Our attention has been called to the excellent work that is being done by the Institution of Junior Engineers. The presidential address was delivered on November 21st by Colonel Edward Raban, C.B., R.E., on "The Preparation of Engineering Projects," and other noteworthy papers during the forthcoming session will include "Marine Boilers," a consideration of the relative values of the different types, by Mr. H. M. Routhwaite, M.I.Mech.E.; "Practical Notes on the Use and Maintenance of Electric Motors for Factory Purposes," by Mr. W. T. George; "Greasy Condensation Water as Boiler Feed," by Mr. William Paterson; and "The Effect of Design on Methods of Construction, from a Contractor's Point of View," by Mr. R. W. Newman, M.I.Mech.E. Between the meetings, visits to works and places of engineering interest in and near London take place at frequent intervals. A great deal of practical knowledge may thus be obtained, and this may be supplemented by borrowing books from the technical library. The Secretary is Mr. Walter T. Dunn, and the offices of the institution are at 39, Victoria-street, Westminster.

On the eve of going to press we have to record, with profound regret, the sudden death of Herr Friedrich Alfred Krupp, of Essen, from apoplexy, on the 22nd ult. Herr Krupp was only in his forty-ninth year, and his sudden demise has caused a profound sensation throughout Germany. The German Emperor addressed the following telegram to the directorate of the firm of Krupp at Essen:—

"The news of the unexpected death of your chief has been a great shock to me. Providence placed Geheimrath Krupp at the head of an enterprise which has achieved a universal significance far beyond the frontiers of the Fatherland. These works, inherited by him from that man of genius, his father, he regarded it as the business of his life not only to maintain but extend in accordance with their reputation throughout the world. His name is most intimately associated with the development of the iron industry and of the whole domain of armaments, including modern fortifications as well as naval construction. In his provisions for the well-being of those in his employment he was unsurpassed, and was a pattern to all. Thus I, to whom the departed was most loyally devoted in patriotic sentiment, share with the managing officials of his works and with the thousands of his workmen, the keenest sense of his loss.—William I.R."

Herr Krupp evinced a kindly interest in Page's Magazine from its foundation, and one of his last literary efforts was the revision of the article recently published on the Germania Ship-building Yard at Kiel.

S. HOWES, 64, MARK LANE, LONDON, E.C.

OWING to the virility of modern inventive genius, and the number of patents bidding for preference, the choice of a turbine has become no easy matter. Those whose business it is to take advantage of water power and secure the best results in the least expensive way, may therefore welcome a few hints on the subject based upon actual experience.

Three points claim attention at the outset, viz., durability, economy in water, and highest efficiency. The prospective user of a turbine will find it desirable to determine whether the appliance under consideration is adapted to his special requirements, and it will also pay him to find out what others have done and are doing in similar circumstances.

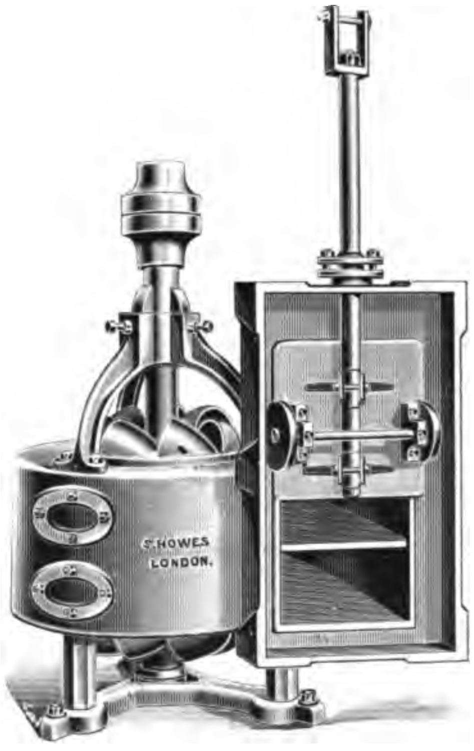
The inquirer is not likely to go very deeply into the matter before discovering that probably one of the largest orders for turbines ever executed, was given by the Canadian Government, who requisitioned no less than 253 of these appliances for use in operating the lock gates of the Welland Canal. This order was placed with Mr. S. Howes, of 64, Mark Lane, whose " Little Giant " Double Turbine held the field against all comers.

The turbine is mounted on a horizontal shaft for use when a direct drive is needed, thus dispensing with gears, etc., and making it particularly applicable for driving electrical machinery.

After the horizontal type had been placed on the market some time, the demand for it and the vertical double turbines was so great, that in order to meet the wants of all buyers it was found necessary to further increase the styles of the " Little Giant " ; particularly for those wishing to develop power under low falls, and for this purpose the " Little Giant " was constructed in an improved case, and is now known as the " Special Flume " Wheel. This latter type is made up to 60 in. in diameter, so that as much as 36 horse power can be obtained under a 4 ft. head. Taking variations of size into consideration, the firm now make no less than 78 kinds of turbines.

Owing to its very high efficiency at part gate, it is suggested that the "Little Giant" Double Turbine can with advantage be applied in every case where there is considerable variation in the water supply, or where it is desirable that the water used should be in direct proportion to the power required. It is well adapted for situations where the water supply is often inadequate to drive the whole of the machinery, and where auxiliary steam power has to be used in dry weather, as it utilises the smallest quantity of water to the best advantage. In the majority of cases the water in winter and summer is variable; not only this, but the head is often reduced by backwater, etc. These and other reasons show why a turbine should give the highest possible efficiency at part gate. The " Little Giant " is a double turbine having two tiers of buckets, or strictly speaking, two turbines, keyed to the same shaft, one above the other, and both running in the same case, the upper tier discharging at the top, and the lower one under the bottom of the case.

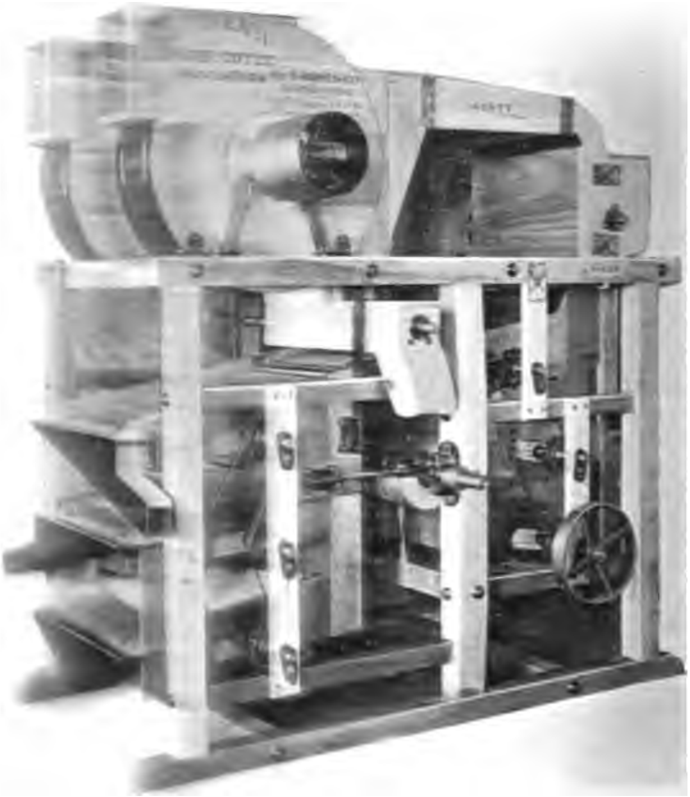
By using this special shape of bucket, curving as it does towards the stream, the water has a steady



"LITTLE GIANT" DOUBLE WATER TURBINE—VERTICAL TYPE.

[illegible] that [illegible] discharged from the wheel. The water [illegible] which the wheel is moving, imparts to it [illegible] the bucket when the water first strikes it, is such that the water [illegible] the friction of water against the bucket at [illegible] hence we have an important advantage over [illegible] opposite direction to the motion of the wheel.

[illegible] is supported at the bottom end and revolves [illegible] orangetree. The case (or guide) is made of [illegible] wheels up to *twenty-four inches in diameter*, are cast



[illegible] COFFEE, RICE, AND SEED SEPARATOR, GRADER, AND CLEANER.

[illegible] be readily opened to remove any obstruction [illegible] This will be best appreciated by those who [illegible] their mills to draw the water from their [illegible] remove some obstruction that could have been [illegible] dissecting it or disturbing the head-gates.

[illegible] the top of case, is made of cast iron, and of [illegible]

[illegible] shaft is bushed with lignum-vitæ. [illegible] in the centre of case, thus preventing [illegible] rubbing against the case.

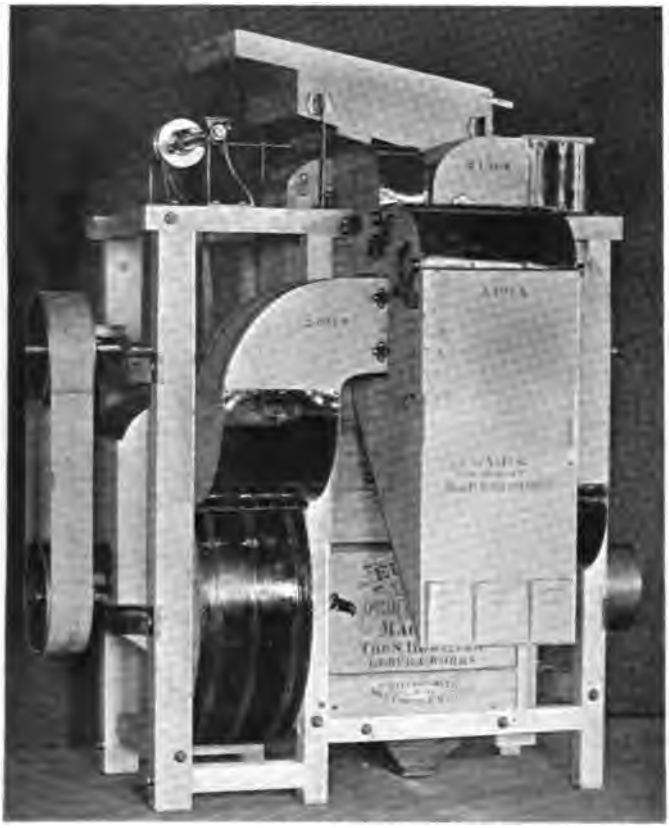
S. Howes, 64, Mark Lane, E.C.

Full information is offered to inquirers who are anxious to adapt the turbine to their special needs. The following questions should be carefully considered by prospective users :—

What is the head of water when at rest, or the vertical distance from surface of head-water to surface of tail-water ?

If the stream is small, what quantity of water can be relied upon ? If the water supply is variable, state how much it varies in wet and dry seasons ; or if an overshot is used, state the diameter and width, and how much the gate was raised to let the water on, and particularly how deep the water was above the gate opening in the forebay.

If the stream is large, state width of same, or, if possible, give us a measurement according to our scheme of instructions for " large open streams."



"EUREKA" HORZ, WHEAT AND BARLEY SCOURING AND BRUSH MACHINE.

What size and make of turbine, if any, is at present, or has been, running ; and how many square inches gate opening is there in the wheel, and how many hours out of twenty-four will the stream afford sufficient water to supply it ?

What kind of machinery is to be driven ?

Give speed of line shaft, and the direction in which it turns.

Give the vertical distance of line shaft from head or tail-water level, and also its distance from the mill floor.

Another speciality of the firm is the " Eureka " wheat, coffee, rice, seed and malt-cleaning, grading, hulling and separating machinery. The accompanying illustrations show two types of over three hundred and fifty manufactured.

The term " Eureka," as applied to milling, grain-cleaning, and elevator machinery, is significant. The extensive range of machinery manufactured under this name had its origin in the early fifties, when, at Silver Creek, N.Y., on Lake Erie, Simeon Howes erected a small plant for the production of his " Smutter." The business owes its present development very largely to Mr. Louis E. Barbeau, who for some years has personally dictated the fortunes of the European branch.

" Eureka " rice graders, hullers, polishers, etc., are now in nearly all the large rice mills of the country. Coffee, also, is being treated with a line of special " Eureka " machines ; and even peanuts are manipulated through all the varying processes of manufacture from the picking of the nuts, etc., to the reduction of the shuck into a powdered form, by " Eureka " machinery. It is not surprising that the original number of distinct models and types of " Eureka " machines is still on the increase, and that Mr. Barbeau has been called upon to supply his machinery in every part of the world.

The firm are also manufacturing a complete line of portable and stationary forges, and hand and power drills.

CATALOGUES AND TRADE PUBLICATIONS.

These catalogues may be had free of charge on application to the firms issuing them. Please mention PAGE'S MAGAZINE when you write. Manufacturers of Engineering and Electrical Specialities, etc., etc., are invited to forward, for review in this column, copies of their catalogues, price lists, and circulars, as soon as issued.

Blumann and Stern, Ltd., Plough Bridge, Deptford, London.—Calendar for 1903, printed in two colours, with separate sheet for each month. The reverse of each leaflet is utilised either as a price list or for descriptions of the firm's specialities, which consist of lubricating oils of all kinds, tallows and greases, etc. A reprint from a recent issue of the *Railway Supplies Journal* is particularly interesting as proving the excellence of the lubricants manufactured by this firm. It is pointed out that during the trials of H.M.S. *Viper*, when the engines developed 12,000 i.h.p., and the mean speed for the six runs showed 36·581 knots, or a velocity equivalent to 43 miles an hour, the lubricants employed throughout were supplied by Messrs. Blumann and Stern.

The Unbreakable Pulley and Mill Gearing Co., Ltd., Manchester and London.—A Treatise on the Economical Transmission of Power. Tenth Edition. 2s. 6d. post free. In the introductory chapter the writers draw attention to the fact that it is not sufficiently realised how important a part the machinery used for the transmission of power has in the general economy of manufacturing establishments, and endeavour to show that a saving of 5 per cent. on the yearly coal bill can be effected. The sometime prejudice, we are told, against the use of cast iron for bearings has practically disappeared, and there is now scarcely a large engineering firm in the kingdom which has not adopted these bearings to a greater or less extent. The authors add : "Any power consumed by shafting beyond the small amount necessary to overcome friction in well designed, truly erected, and properly lubricated bearings, is absolutely wasted ; yet, though people will look closely enough into the economy of the engine or machines they are going to buy, economy in the means by which power is transmitted from the engine to the machines is constantly overlooked, generally also the economy in erection, while the sole care is to buy from the man who will supply so many feet of shafting and so many bearings at the lowest price." The main object of the work, we gather, is to set out as concisely as possible the rules upon which an engineer should work in designing a system of shafting for a factory, with full tables of strengths, weights, powers, and velocities, so that the book may serve as a handy reference for the skilled designer, and a trustworthy guide for those who have no special knowledge of the subject, but who desire to plan their own arrangements. We certainly think it is a valuable work, and well worthy of being consulted on any of the above points. The subject matter is suitably arranged and concisely written. A very readable type is employed and the quality of the half-tone illustrations and woodcuts leaves little to be desired.

William Ryder, Ltd., Bolton, Lancs.—Illustrated Catalogue of Forging Machines, Sawing Machines, and other tools, with prices. The booklet, which is printed in two colours, is well designed, and is illustrated by means of some excellent wood cuts. The principal speciality is the now well-known Forging Machine, made in various designs with three to five pairs of steel blocks, or hammers, and in weight varying from 25 cwt. to 5 tons. The sawing machines, which are very frequently used in the smithy in conjunction with forging machines, are made in various sizes and weights, and with sawing capacities for hot iron bars varying in thicknesses from 3 to 6 in.

The Clyde Structural Iron Company, Ltd., of Scotstoun, Glasgow.—A neat little booklet of forty pages and cover, comprising a catalogue of structural iron and steel work as manufactured and erected by the company. The illustrations include some interesting designs for curved roofs, agricultural sheds, stores, granaries, dock sheds, market place or bazaar, drill and public halls, swimming baths, tea factories, gold mine buildings, engineering shops, bungalows, bridges, etc., etc. With regard to the photographs of recent work carried out by the firm, we quite agree with their remarks, that these serve better than any quantity of letterpress to indicate the kind of work they are prepared to execute. They include excellent examples of railway, foundry, and other work.

Graham, Morton and Co., Ltd., Leeds.—A neat little brochure of fifty-two pages and cover, entitled "Elevating and Conveying Machinery," being a description, with numerous illustrations of an economic method of transportation of coal and minerals. The system consists of a plant by means of which coal or other material is automatically conveyed from one given point to another, thus saving, it is claimed, 80 per cent. of labour cost. The illustrations include reproductions from photographs of (1) a plant to handle coal and store it in coal stores at the rate of 30 tons per hour ; (2) an elevating plant at the generating station of the Leeds City Tramways, which conveys coal from boat to boiler furnace at a total labour cost of 1d. per ton ; (3) a plant erected to weigh, handle, and store coal at the rate of 40 tons per hour ; (4) a large conveyor, over 400 ft. long, erected for carrying 150 tons of coal per hour ; (5) conveying plant erected for feeding a water-tube boiler and a series of Lancashire boilers. The coal is brought automatically from the coal stores by means of continuous conveyors, and (6) a conveyor which carries sacks of flour at the rate of 1,000 per hour. Other illustrations show screening, measuring, and weighing plants, belt conveyors, storage bunkers, a novel coal-tipping apparatus—by means of which a railway truck can be automatically tipped and emptied at once—spiral conveyors, etc., etc.

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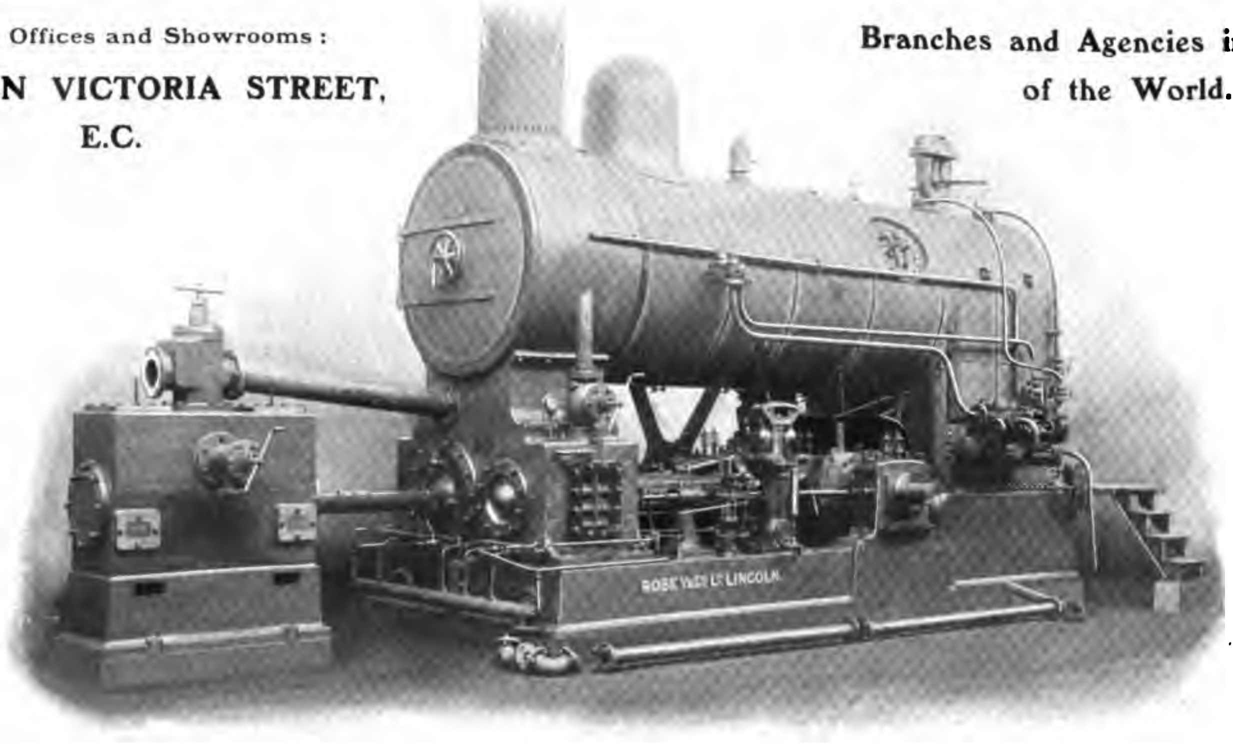

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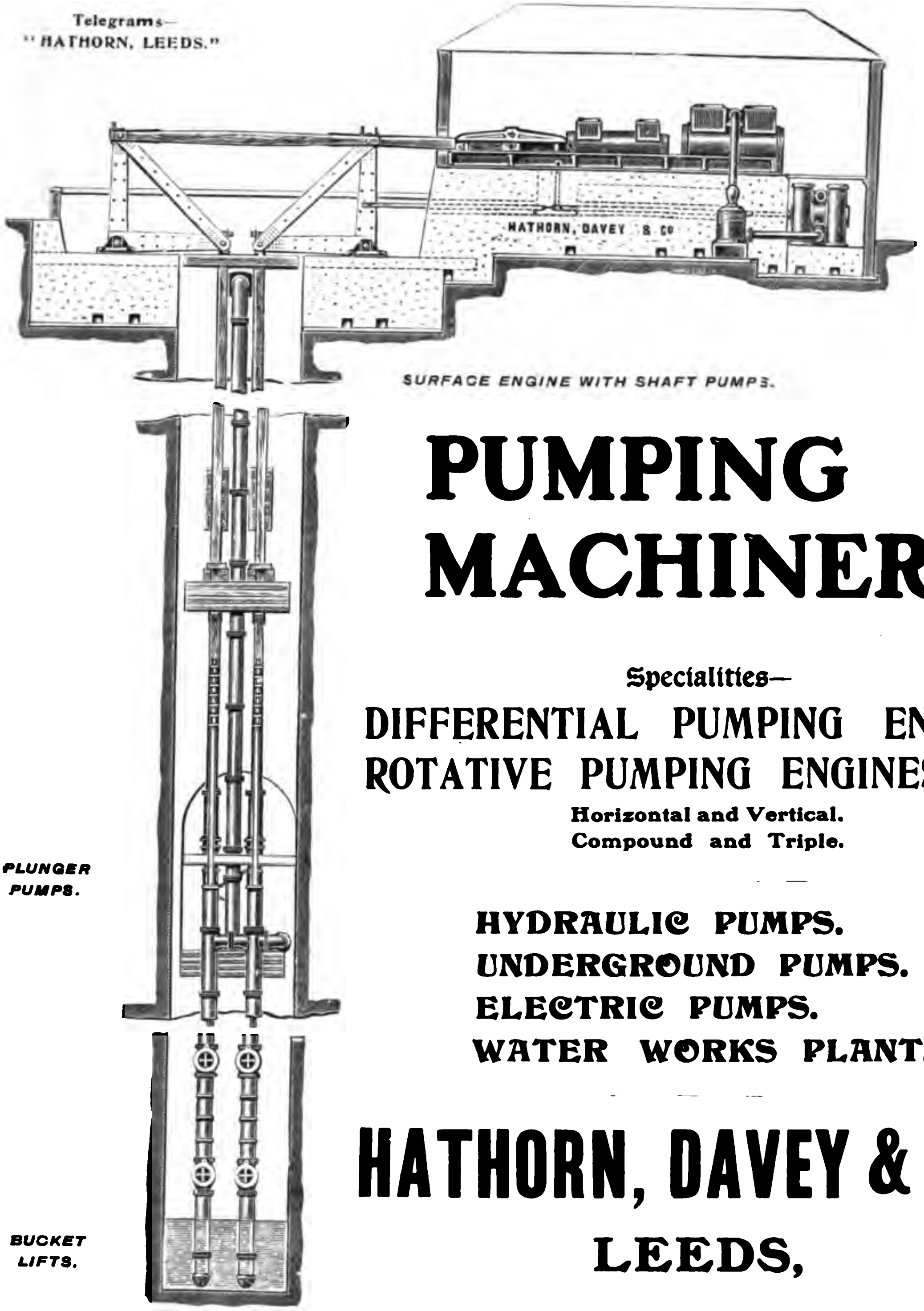

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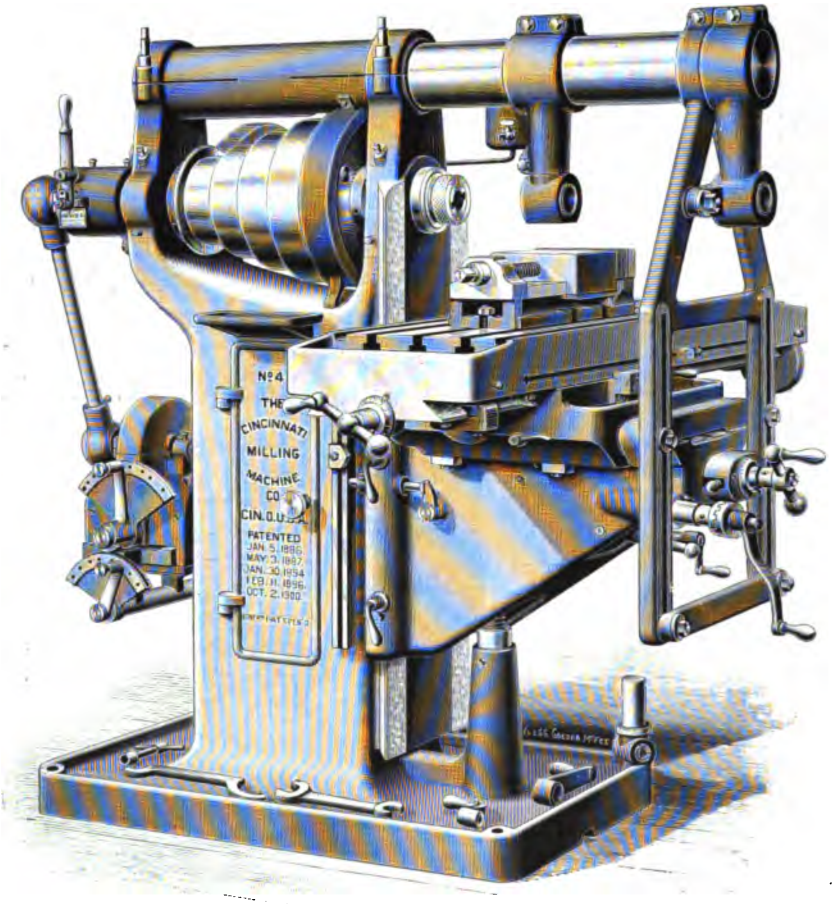

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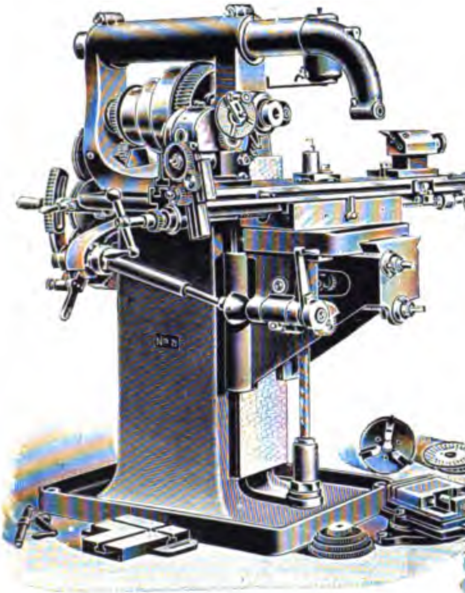

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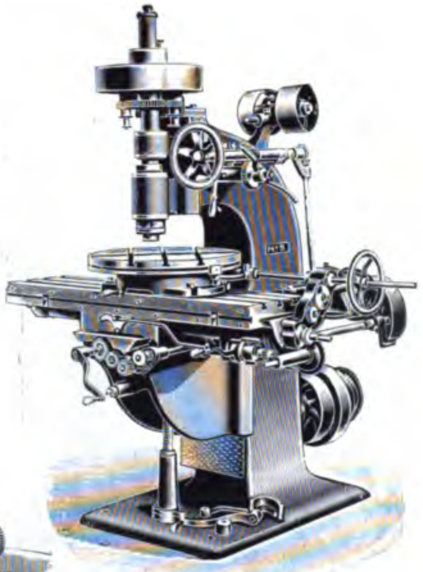

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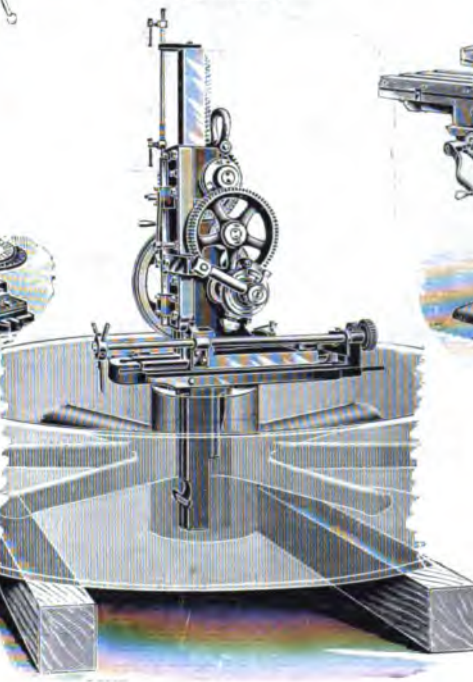

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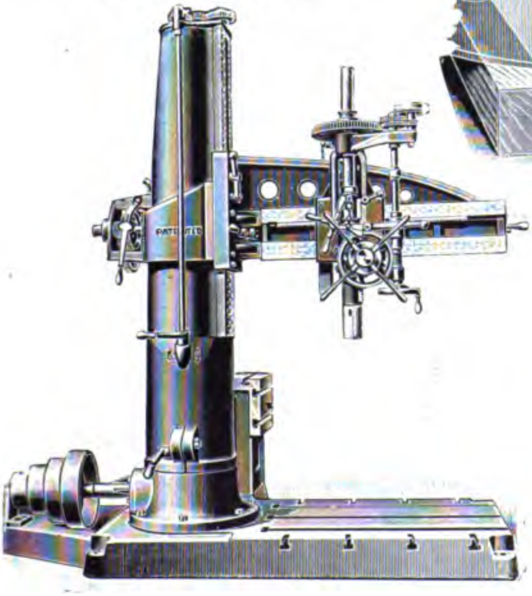

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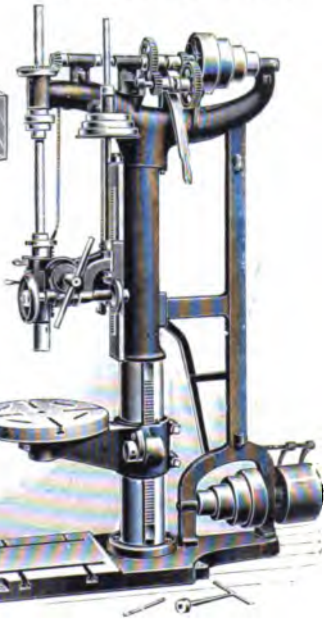

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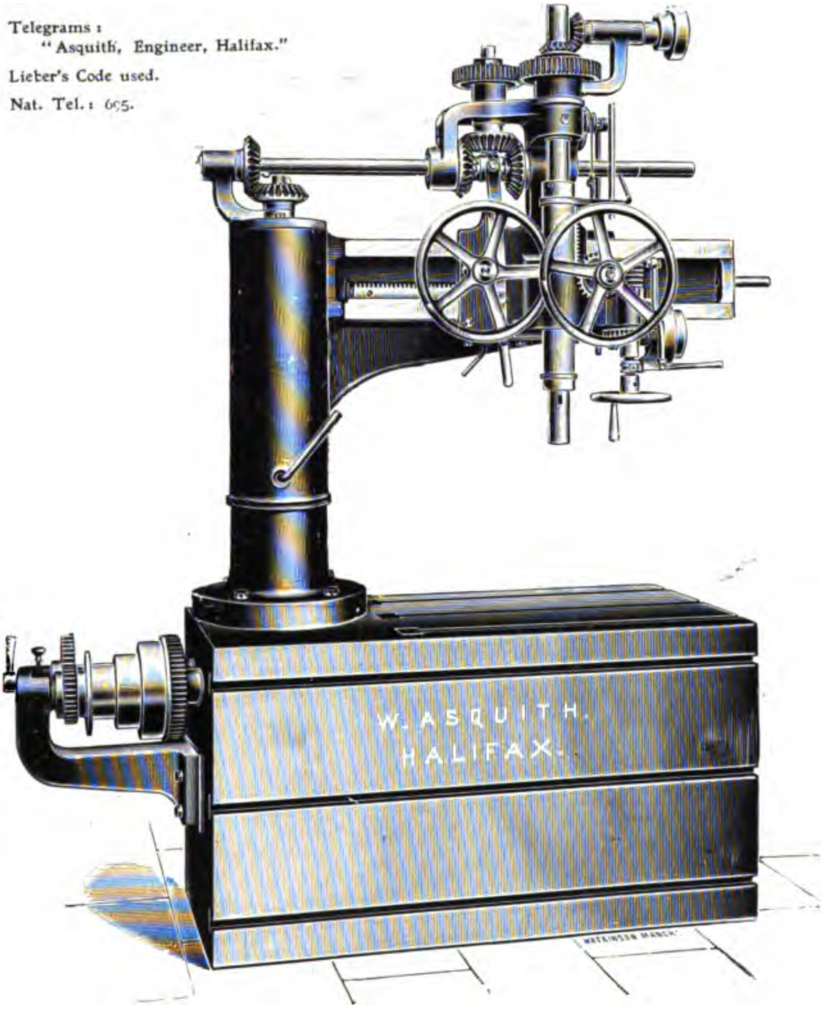
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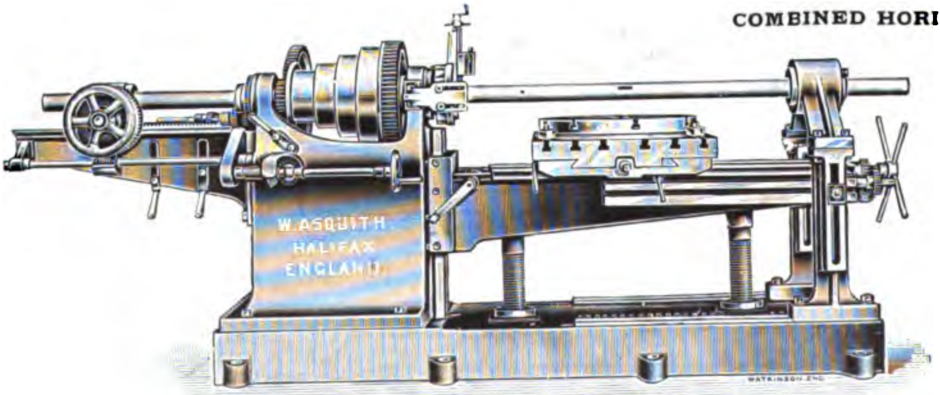

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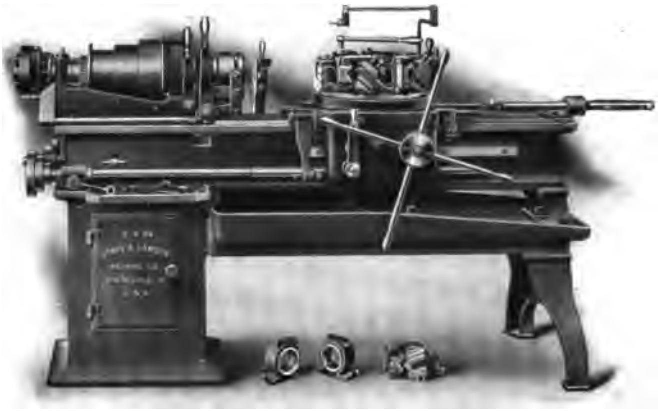

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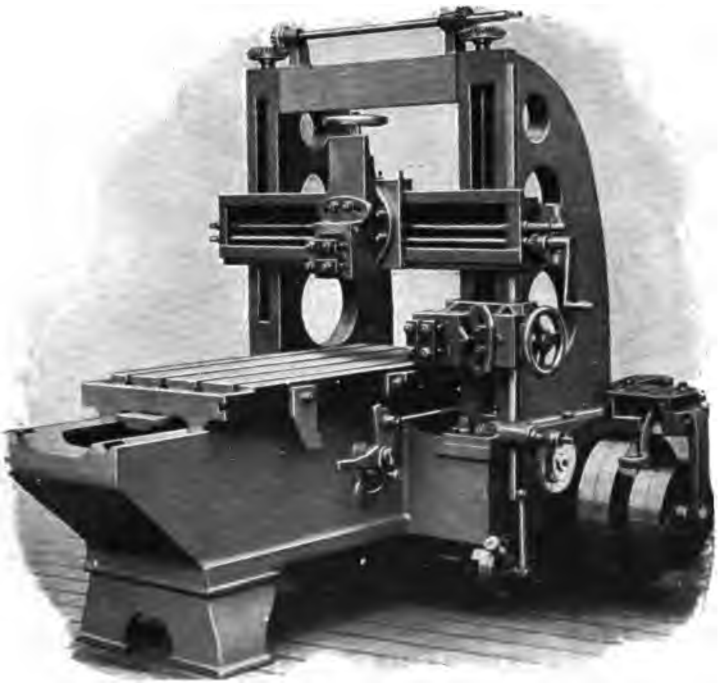

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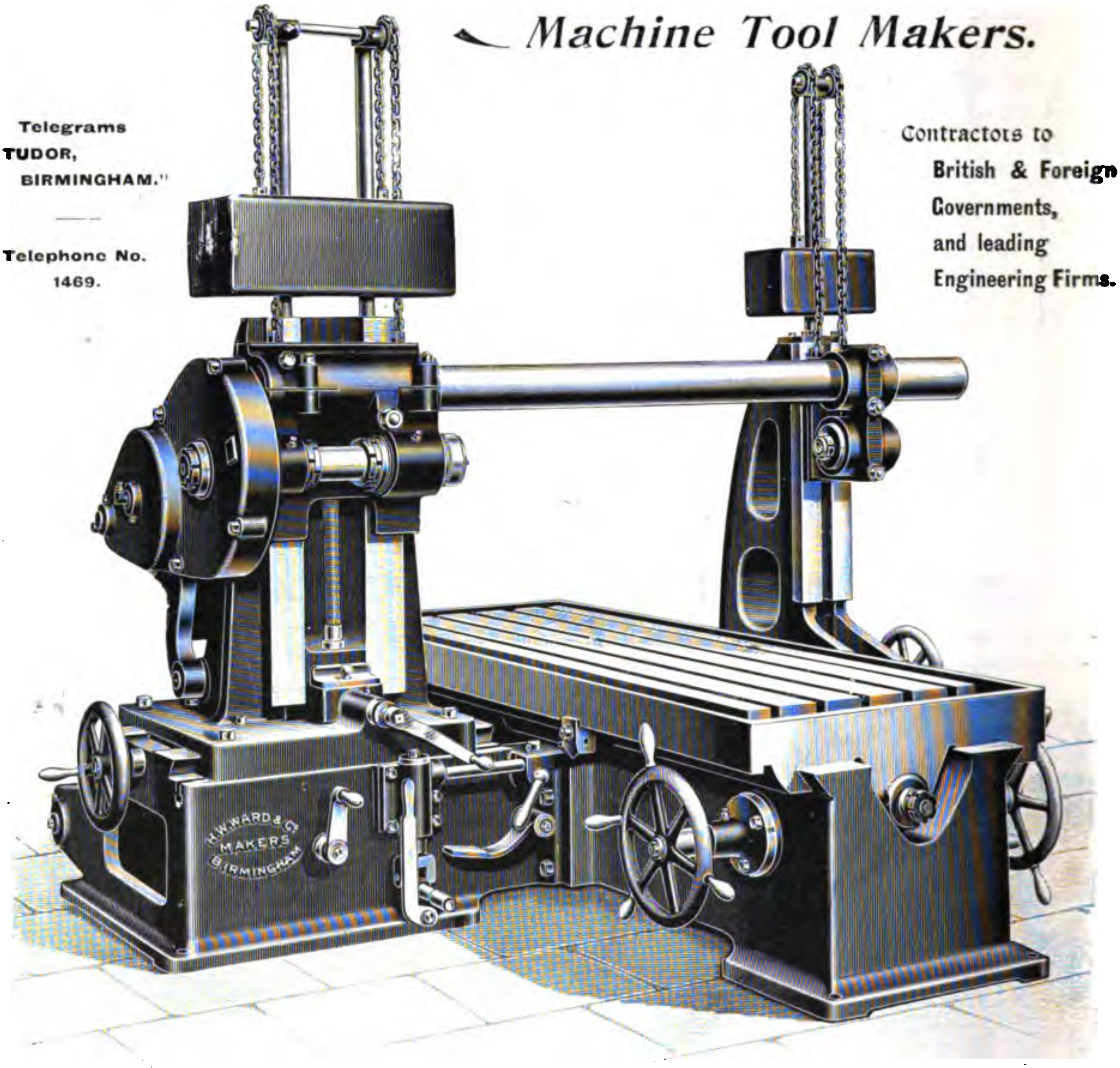

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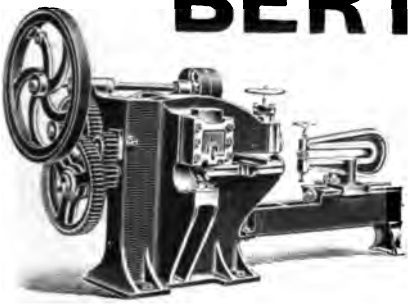

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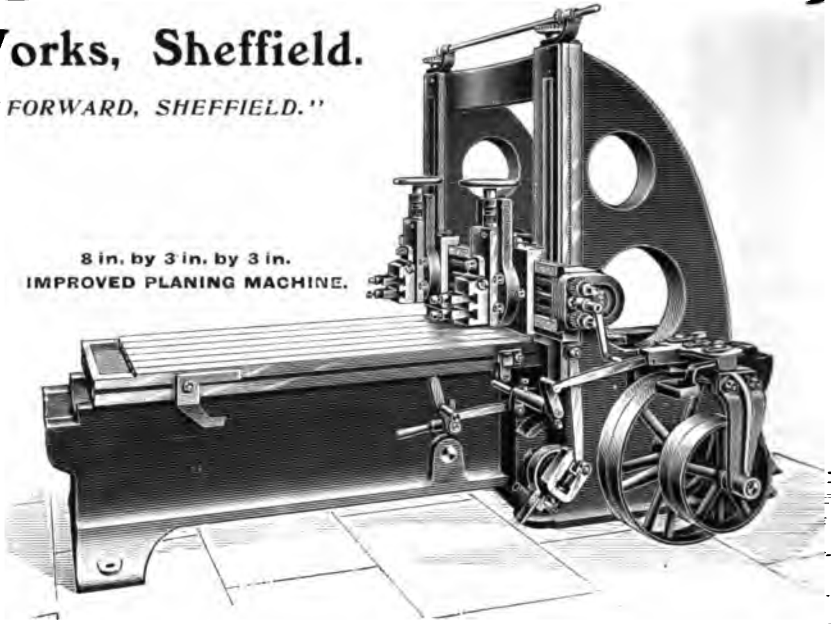

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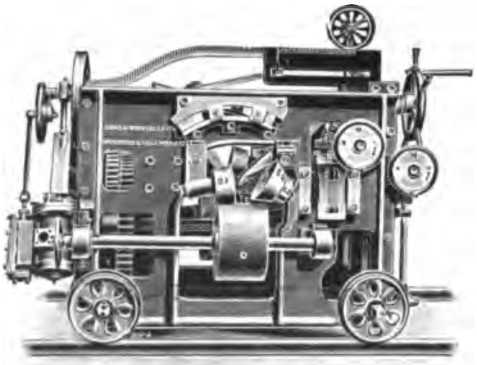

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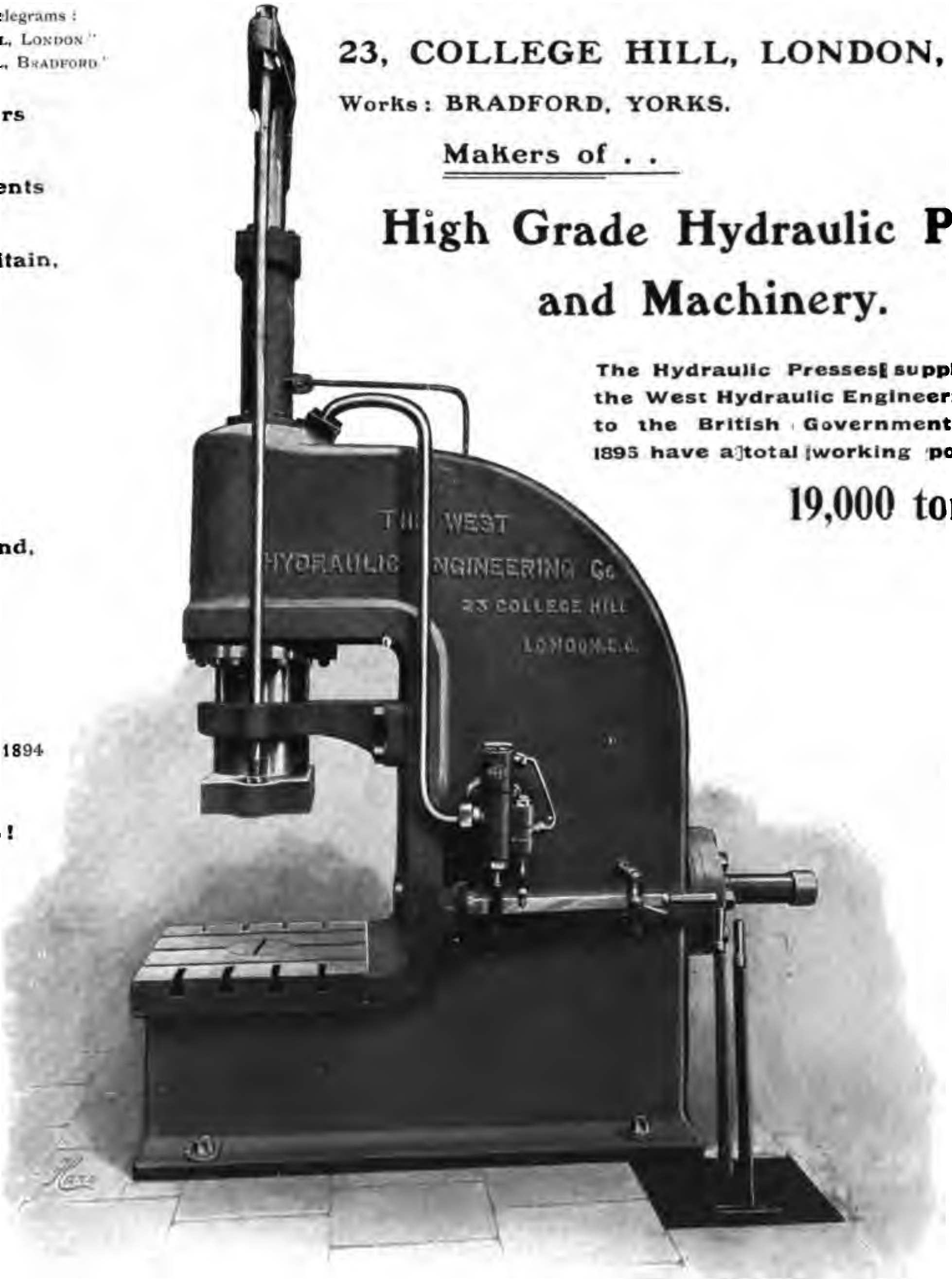
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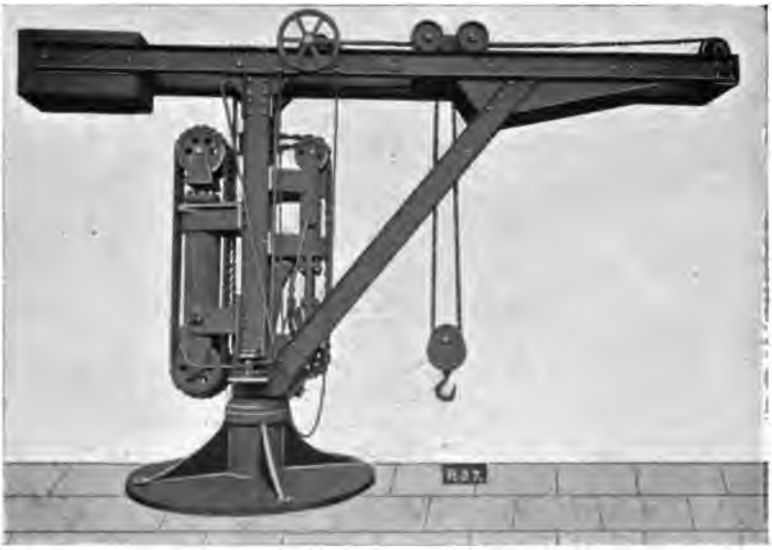

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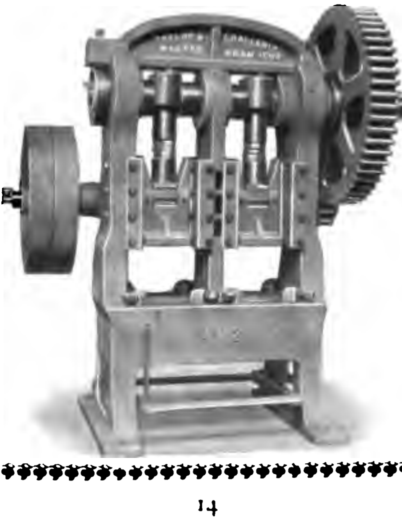

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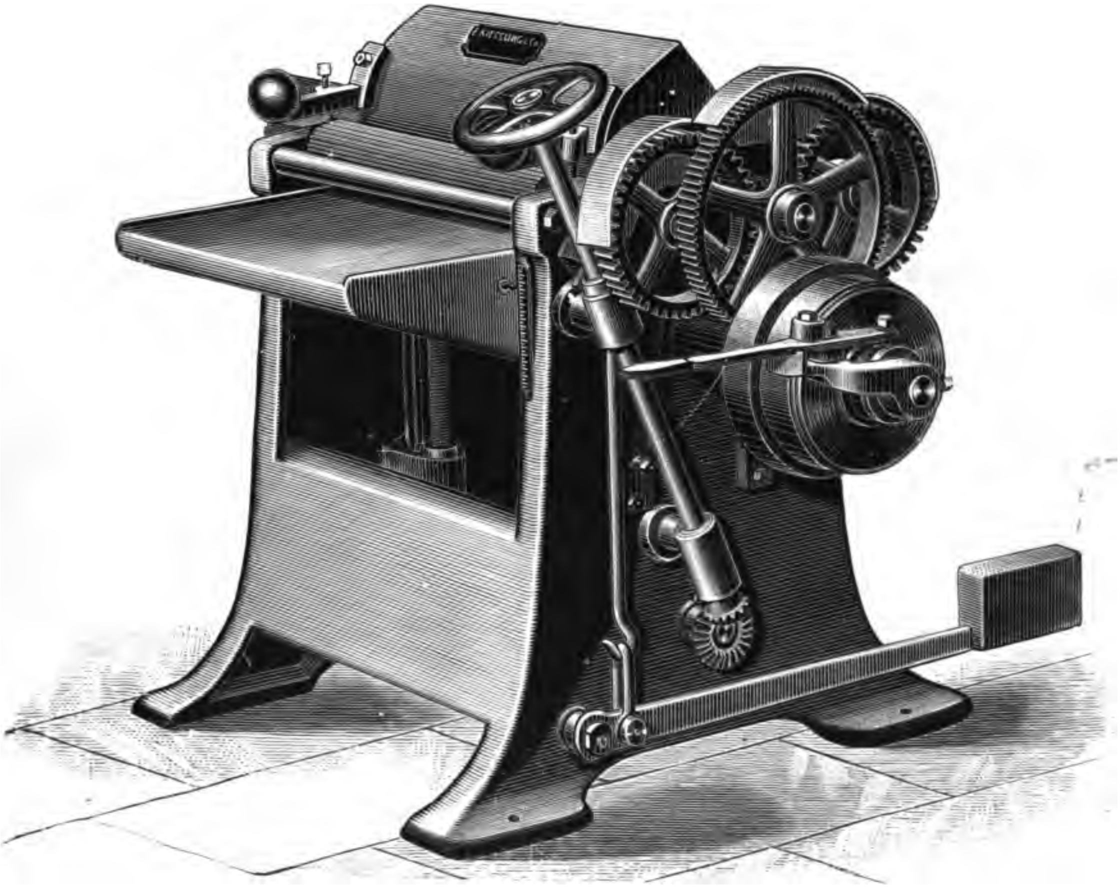

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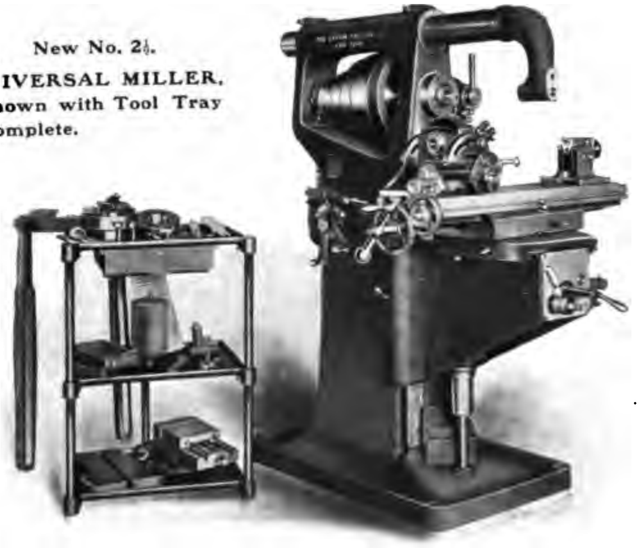

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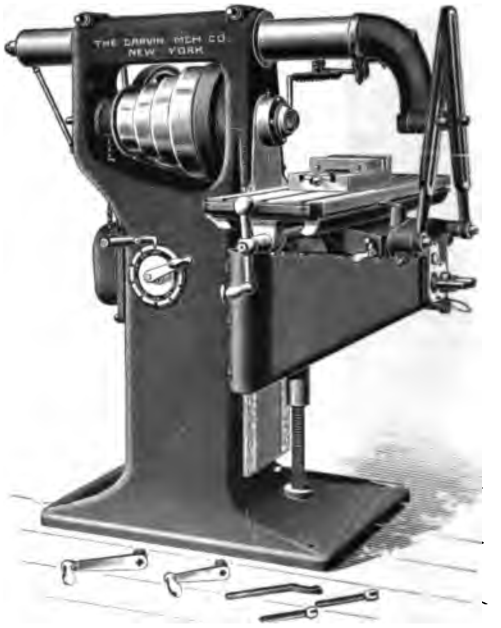

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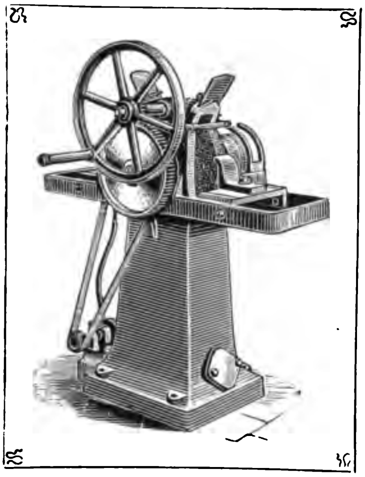

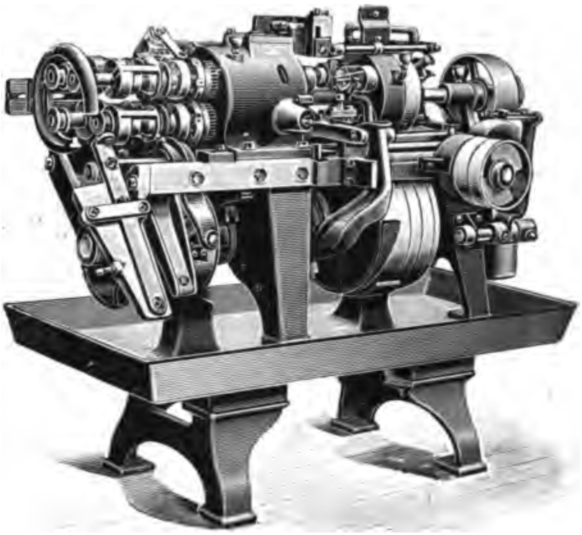

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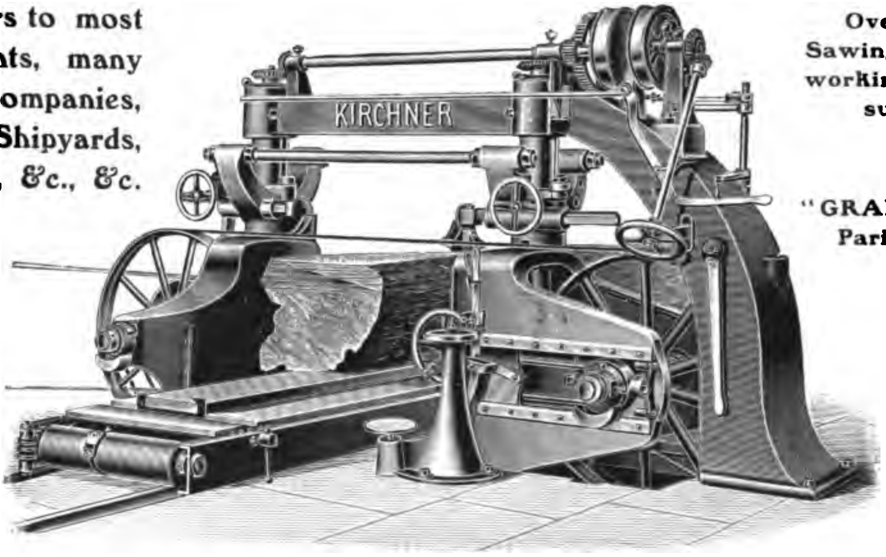

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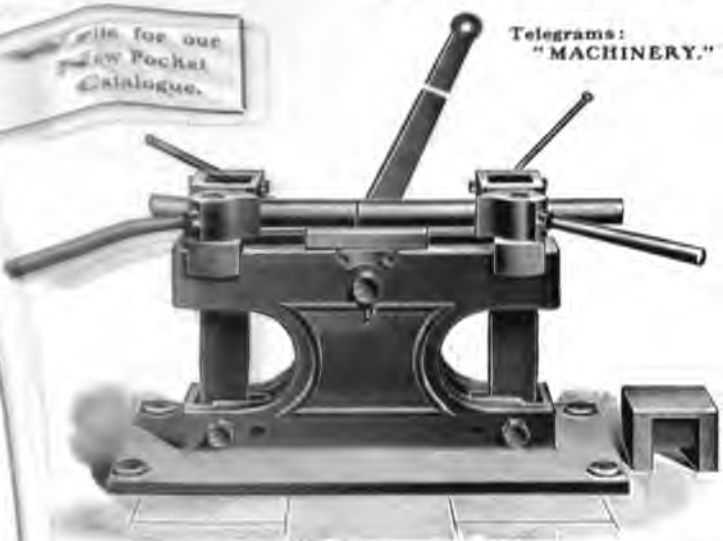

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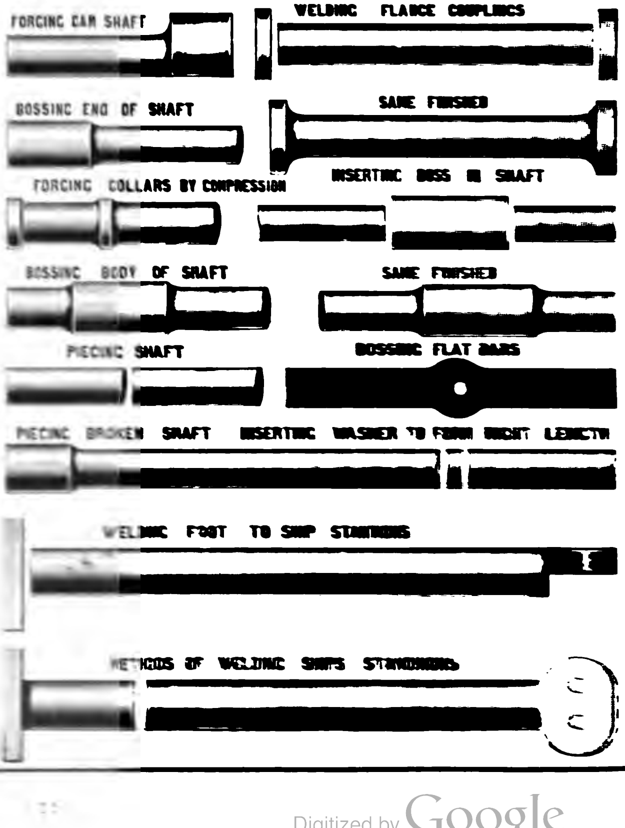

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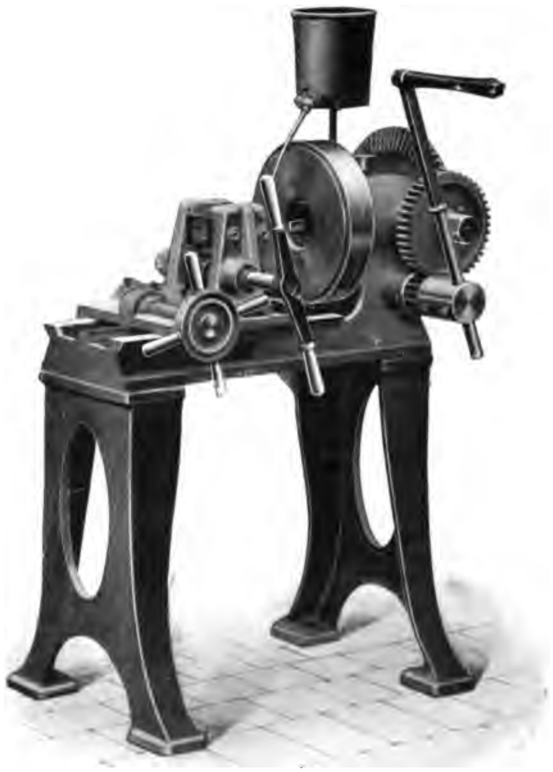

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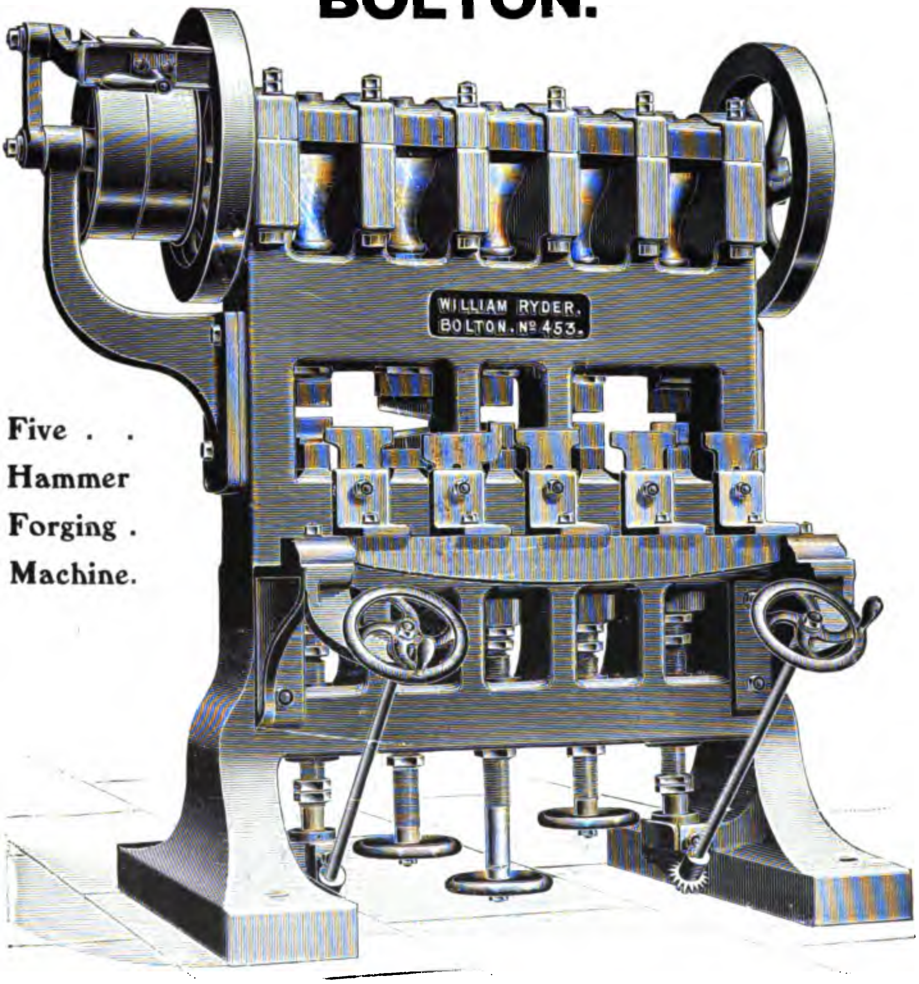
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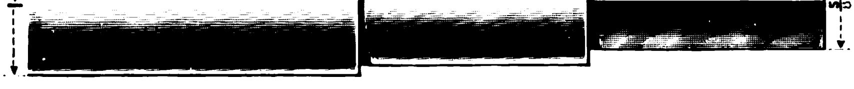

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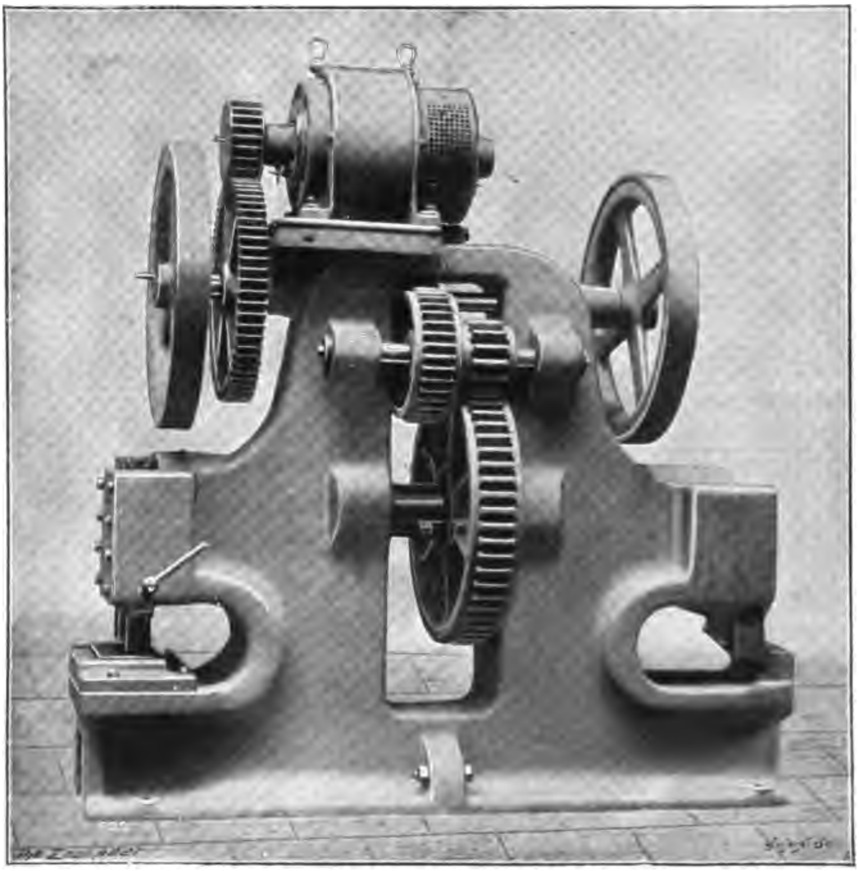

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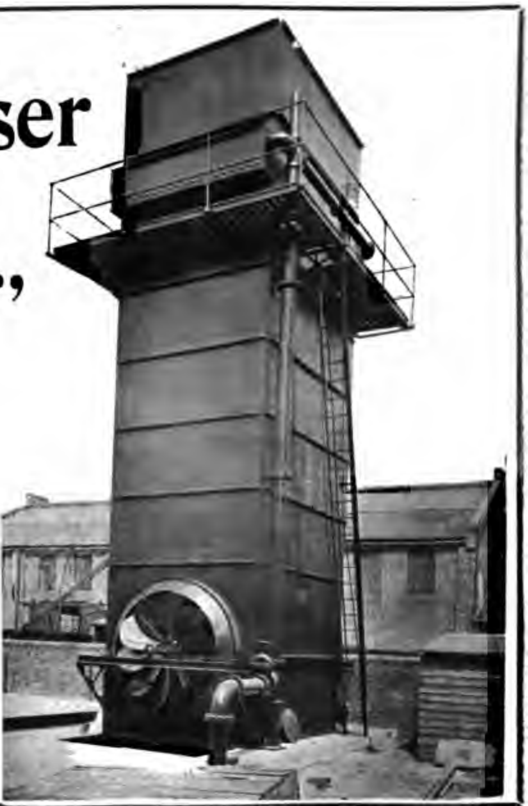

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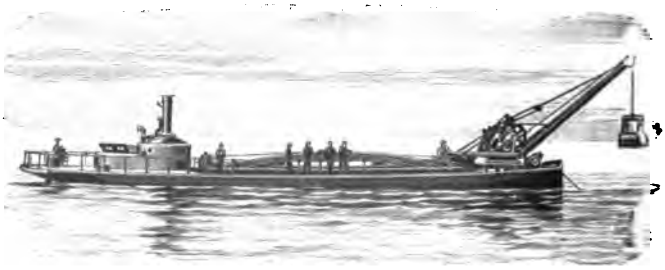

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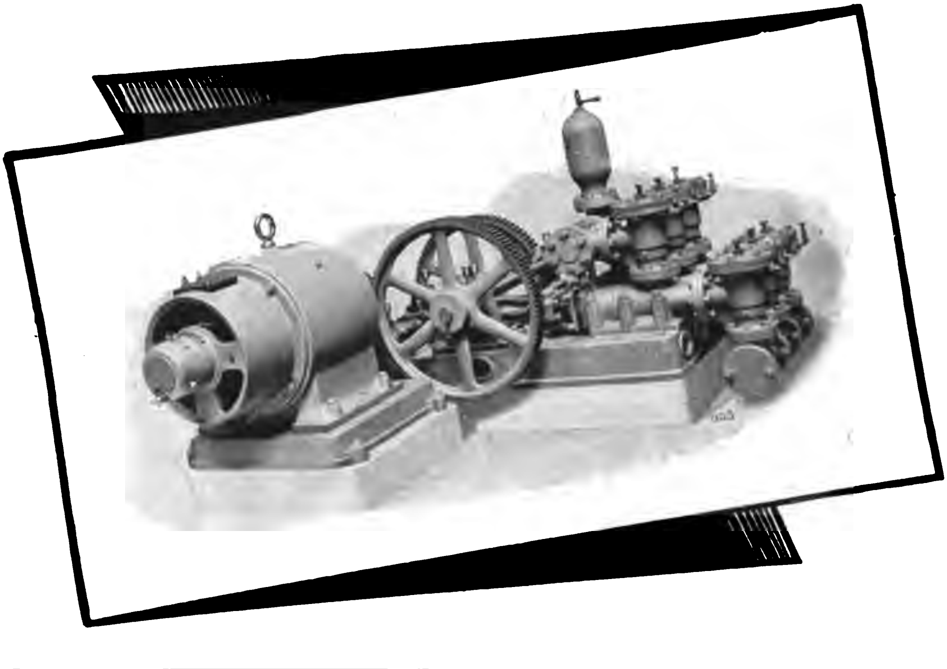

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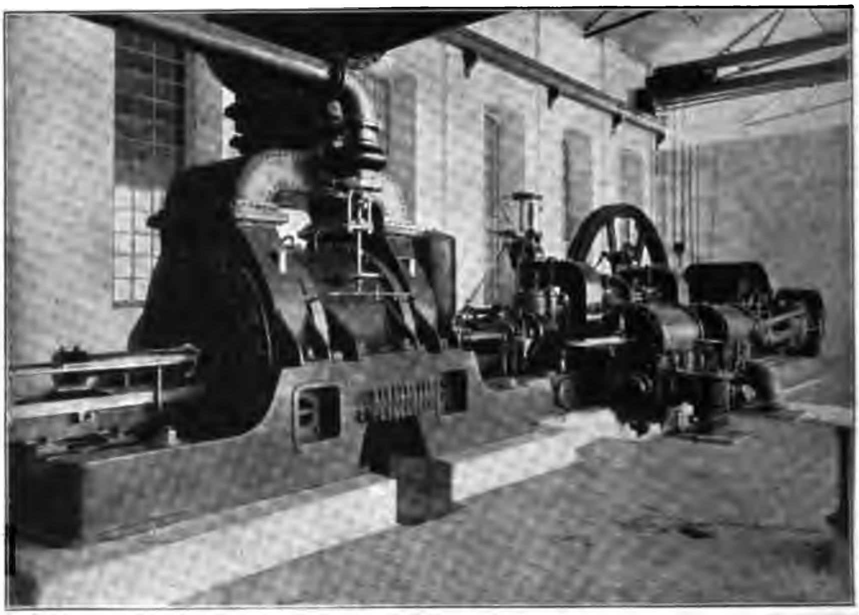

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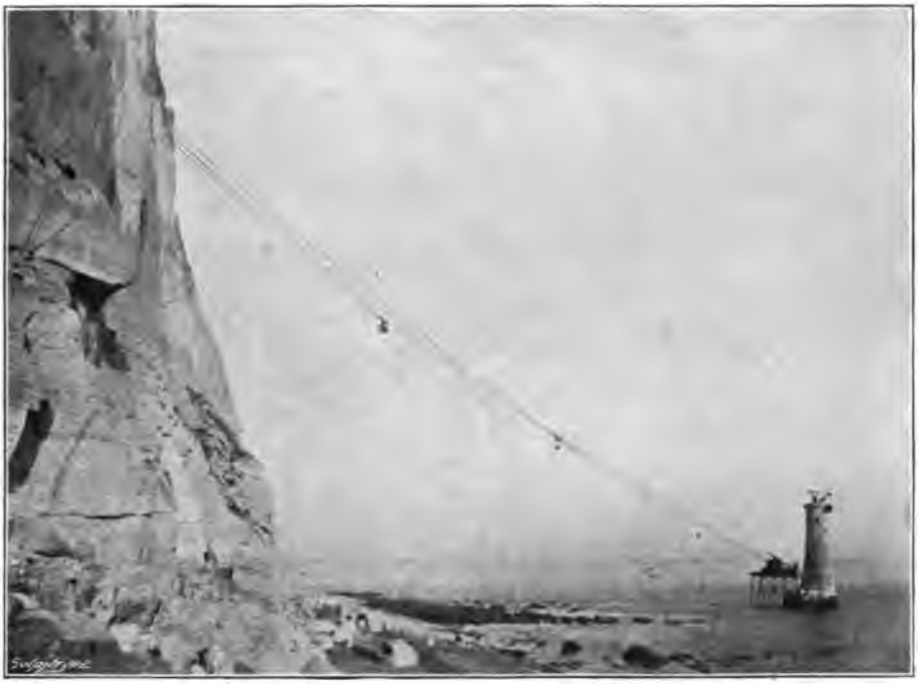

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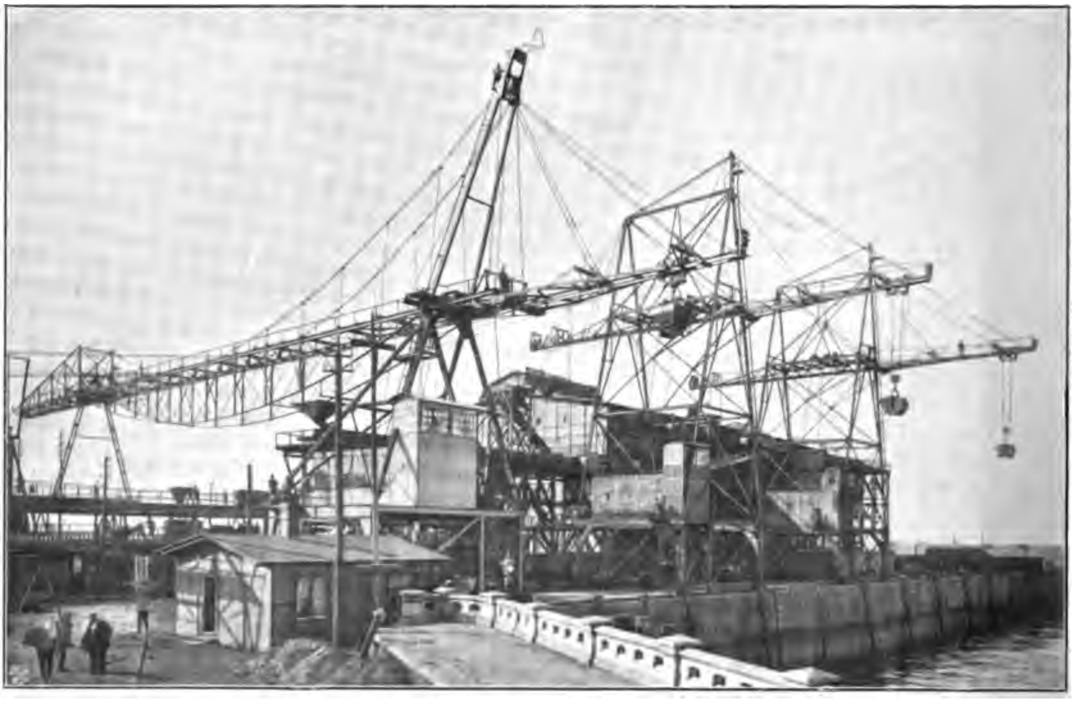

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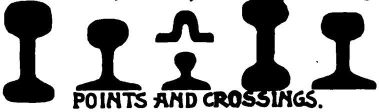

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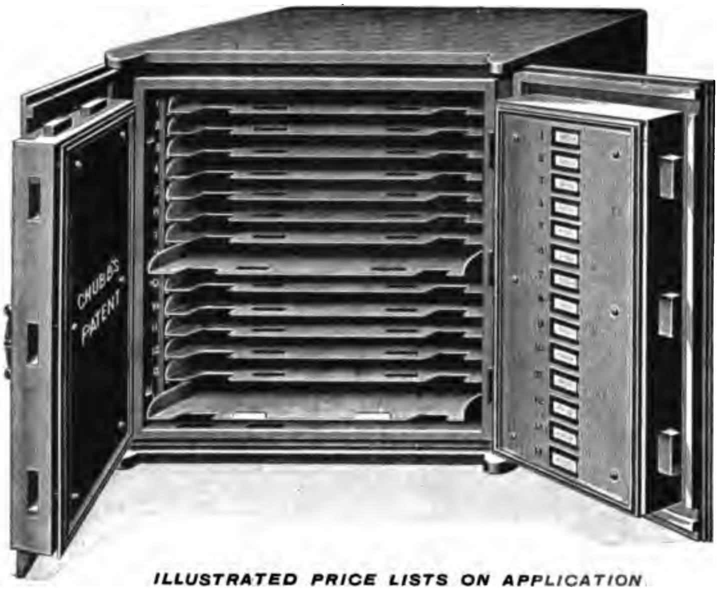

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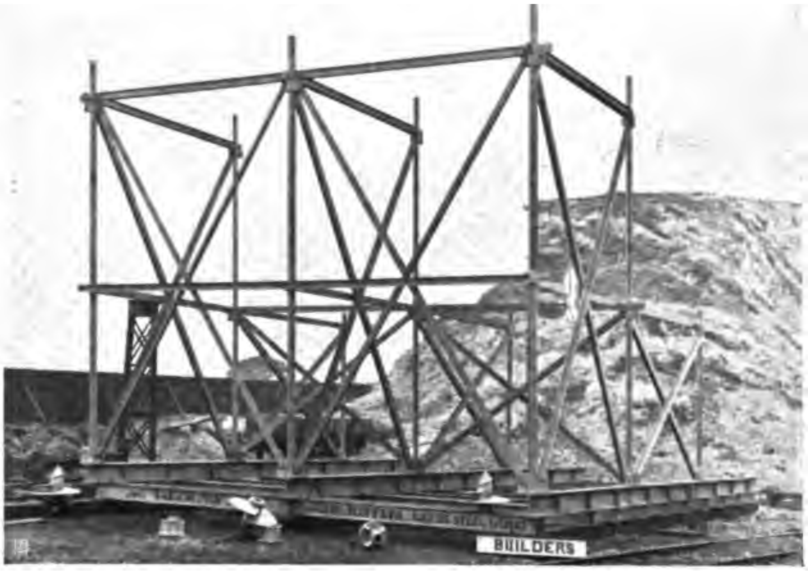

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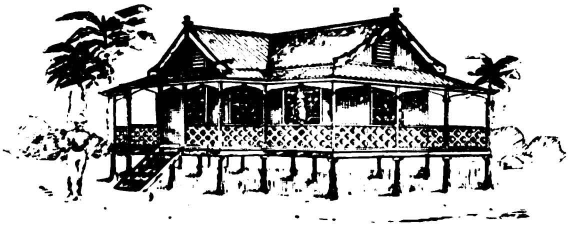

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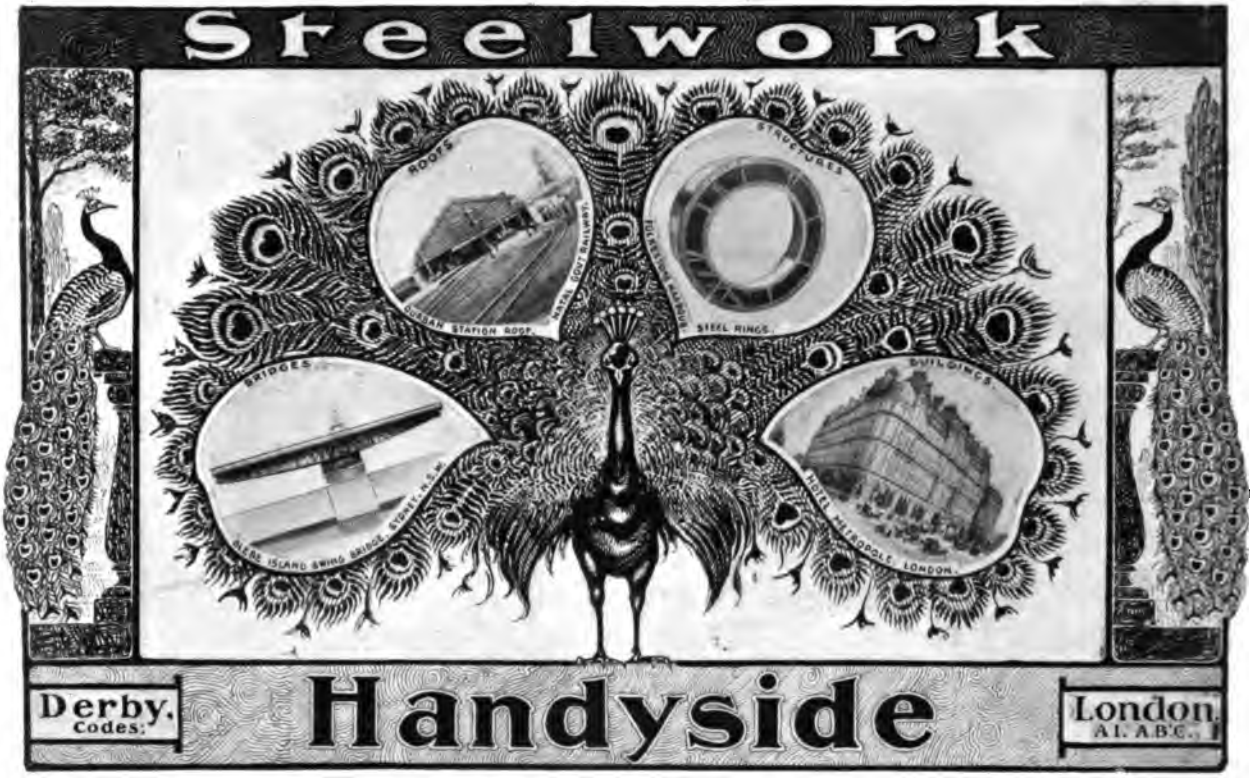

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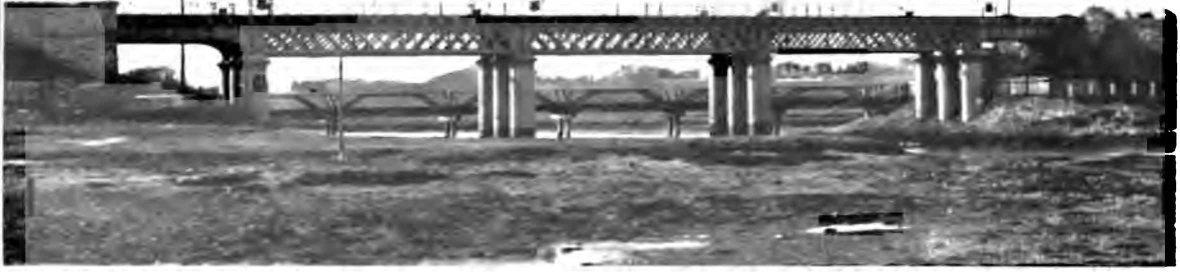

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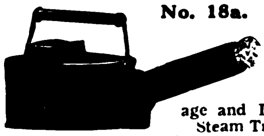

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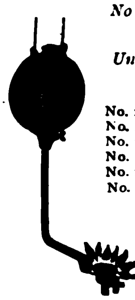

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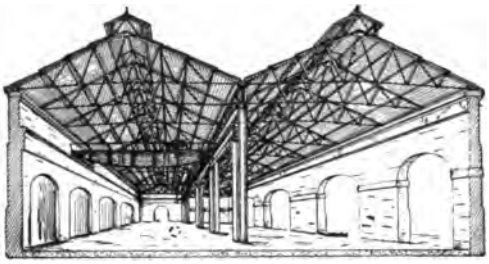

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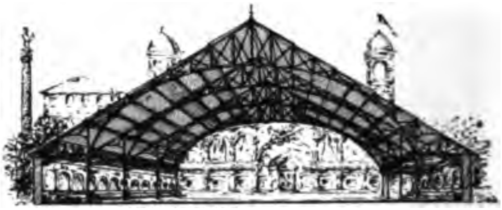

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INDEX·TO·ADVERTISERS

PAGE
Addy, George, & Co. ... 12
Allgemeine Elektricitäts-Gesellschaft ... 64
Anderson, D., & Son, Ltd. ... 37
Armstrong, Stevens & Son ... 34
Ashton, Thomas A., Ltd.... ... 73
Asquith, W. ... 8
Atlas Metal and Alloys Co., Ltd. ... 88
Auto Machinery Co., Ltd. ... 71

Babcock and Wilcox, Ltd. ... 75
Bayliss, Jones & Bayliss... ... 40
Becker & Co. ... —
Bertrams, Ltd. ... 11
Blake and Knowles' Steam Pump Works, Ltd. ... 69
Bleichert, Adolf, & Co. ... 28
Blumann & Stern, Ltd. ... 41
Booth, Joseph & Brothers, Ltd.... ... 62
Bridge, David, & Co. ... 97
Britannia Engine and Tool Factory ... 4
British Steam Specialties, Ltd. ... 100
Brown Bayley's Steel Works, Ltd. ... 31
Brown Hoisting Machinery Co. ... 48
Brush Electrical Engineering Co., Ltd. ... 57
Buffoline Noiseless Gear Co. ... 11
Bullivant & Co., Ltd. ... 27
Burton, C. W., Griffiths & Co. ... 16

Calyx (New) Drill and Boring Co., Ltd. ... 23
Chubb & Sons Lock & Safe Co., Ltd.... ... 34
Churchill, Charles, & Co., Ltd. ... 6
Clarke's Crank & Forge Co., Ltd. ... 35
Clayton, Son & Co., Ltd.... ... 76
Cleveland Bridge Co. ... 38
Combination Metallic Packing Co., Ltd. ... 72
Consett Iron Co., Ltd. ... 30
Crompton & Co., Ltd. ... 21
Crowther, H. ... 88
Cunliffe & Croom, Ltd. ... 9

Davidson & Co., Ltd. ... 67

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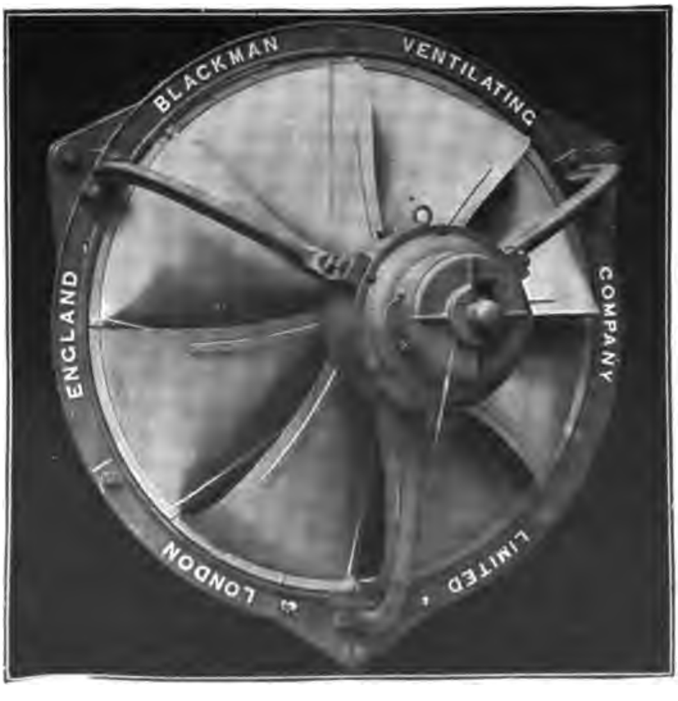

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Index to Advertisers—(Contd.)

	PAGE
Davies & Sons, Richard	36
Davis & Primrose	12
Deighton's Patent Flue & Tube Co., Ltd.	81
Drum Engineering Co.	68
Farnley Iron Co., Ltd.	35
Firth, William, Ltd.	32
Fleming, Birkby & Goodall, Ltd.	100
Fowler, John, & Co. (Leeds), Ltd.	59
Fraser & Chalmers, Ltd.	26
Frictionless Engine Packing Co., Ltd.	71
Galloways, Ltd.	58
Gilkes, G., & Co., Ltd.	68
Glover, M., & Co.	82
Graham, Morton & Co.	29
Green, E., & Son, Ltd.	Inside Back Cover
Greenwood & Batley, Ltd.	63
Griffin, Charles, & Co., Ltd.	43
Gunther, W., & Sons	68
Hadfield's Steel Foundry Co., Ltd.	57
Halden, J., & Co.	66
Hall, J. P., & Sons, Ltd.	90
Hammond Typewriter Co.	98
Handyside, Andrew, & Co., Ltd.	38
Hardy Patent Pick Co. Ltd.	1
Hathorn, Davey, & Co., Ltd.	5
Hindley, E. S.	100
Horsfall Destructor Co.	—
Howard Bros.	87
Howes, S.	89
Hughes & Lancaster	44
Hughes, G. H.	4
Humbolt Engineering Works Co.	24
Hunslet Engine Co.	60
Hunt & Mitton	84
International Electrical Engineering Co.	63
International Time Recording Co.	86
Jones & Lamson Machine Co.	9
Judd, Walter, Ltd.	—
Kaye, Joseph, & Sons, Ltd.	74
Keep, Juxon & Co.	32
Keith, J., & Blackman Co., Ltd.	42
Kiessling's Machine Co.	15
Kirchner & Co.	17
Krupp, Fried.	32

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Index to Advertisers—(Contd.)

PAGE
Lancaster & Tonge, Ltd. ... 71
Lassen & Hjort ... 75
Leeds Forge Co., Ltd. ... 82
Library Bureau, Ltd. ... 93
Library Supply Co. ... 85
Lobnitz & Co., Ltd. ... 22
Luke and Spencer, Ltd. ... 17
Lyle Co., Ltd. ... 99

Mabie, Todd & Bard ... 97
McInnes, T. S., & Co., Ltd. ... 97
McLaren, J. & H. ... Back Cover
McPhail & Simpsons' Dry Steam Patents Co., Ltd.... 92
Magnolia Anti-Friction Metal Co., Ltd. ... 47
Main, A. & J., & Co., Ltd. ... 40
Mason, W. F., Ltd. ... 80
Matthews & Yates, Ltd. ... 42
Meldrum Bros., Ltd. ... 83
Melling, J. F. ... 90
Met. Amalgamated Ry. Carriage & Wagon Co., Ld. 46
Mills, Edwin, & Son ... 75
Mosses & Mitchell ... 73

PAGE
Naylor, J. G., & Co., Ltd. ... 67
Nicholson Tool Co. ... 18

Parker Foundry Co. ... 32
Parkinson, J., & Son ... 11
Pekrun Maschinen-Fabrik ... 81
Periam, H. W. Ltd. ... 83
Phœnix Dynamo Co. ... 79
Phosphor Bronze Co., Ltd. ... 23
Piggott, Thos., & Co., Ltd. ... 78
Pochin, E. Arnold ... 88
Polishers' Supply Co. ... 100
Portable Building Co., Ltd. ... 37
Pulsometer Engineering Co., Ltd. ... 45

Reliance Lubricating Oil Co. ... 14
Renshaw, W. R., & Co., Ltd. ... 61
Rockwell-Wabash Co., Ltd. ... 96
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Index to Advertisers—(Contd.)

	PAGE
Rose, Downs & Thompson, Ltd.	22
Rowland, B. R., & Co.	91
Ryder, William, Ltd.	20
Schischkar & Co., Ltd.	17
Scotch & Irish Oxygen Co., Ltd.	66
Scott & Mountain, Ltd.	25
Scott, Walter, Ltd.	36
Selig, Sonnenthal & Co.	7
Shannon, Ltd.	95
Simplex Steel Conduit Co., Ltd.	41
Southwood, Smith & Co., Ltd.	94
Spon, E. & F. N.	4
St. Helen's Cable Co., Ltd.	65
Stamm, W.	20
Standard Engineering Co., Ltd.	67
Stirling Co. of U.S.A.	89
Süddeutsche Kabelwerke, A.-G.	66
Summerscales & Sons, Ltd.	70
Swain & Son, Ltd.	91
Tangyes Ltd.	70
Taylor & Challen, Ltd.	14
Teale & Co.	73
Thom, John G.	90
Thornycroft Steam Wagon Co., Ltd.	82
Transportation Development Co.	61
Treasure, J. B.	90
Triumph Stoker, Ltd.	97
Tubes, Ltd.	77
Turri & Co.	22
United States Metallic Packing Co., Ltd.	72
Vacuum Oil Co., Ltd.	74
Von der Heyde, J. Bennett	68
Ward, H. W., & Co.	10
Ward, T. W.	12
Waygood & Otis, Ltd.	98
Weldless Steel Tube Co., Ltd.	78
Wells, A. C., & Co.	39
West Hydraulic Engineering Co.	13
Westinghouse Co., The British	Inside Front Cover
Wheeler Condenser and Engineering Co.	22
Wilfley Ore Concentrator Syndicate, Ltd.	23
Willcox, W. H., & Co., Ltd.	73
Williams, J. H., & Co.	31
Winn, Charles, & Co.	19
Woodhouse & Rixson	33
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Wyckoff, Seamans & Benedict	9

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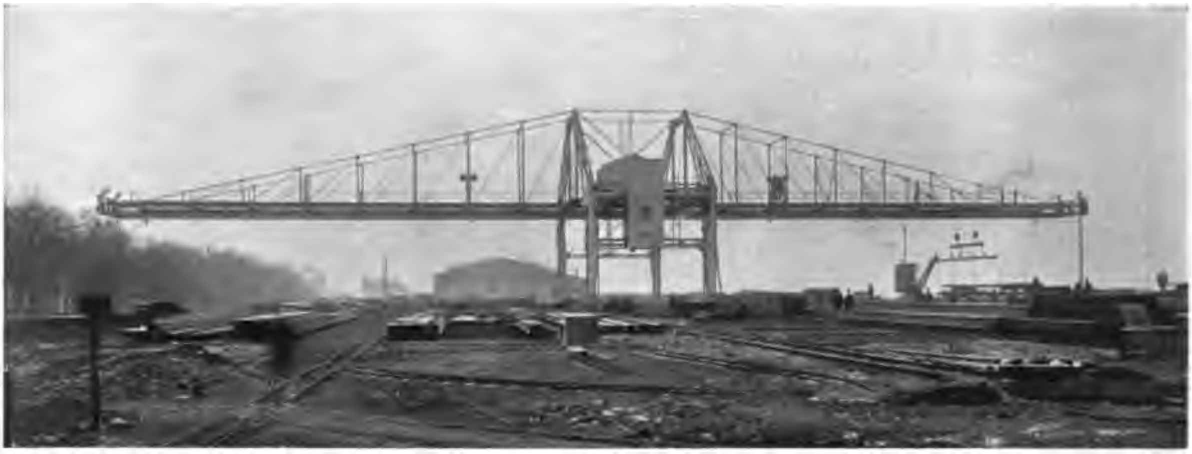

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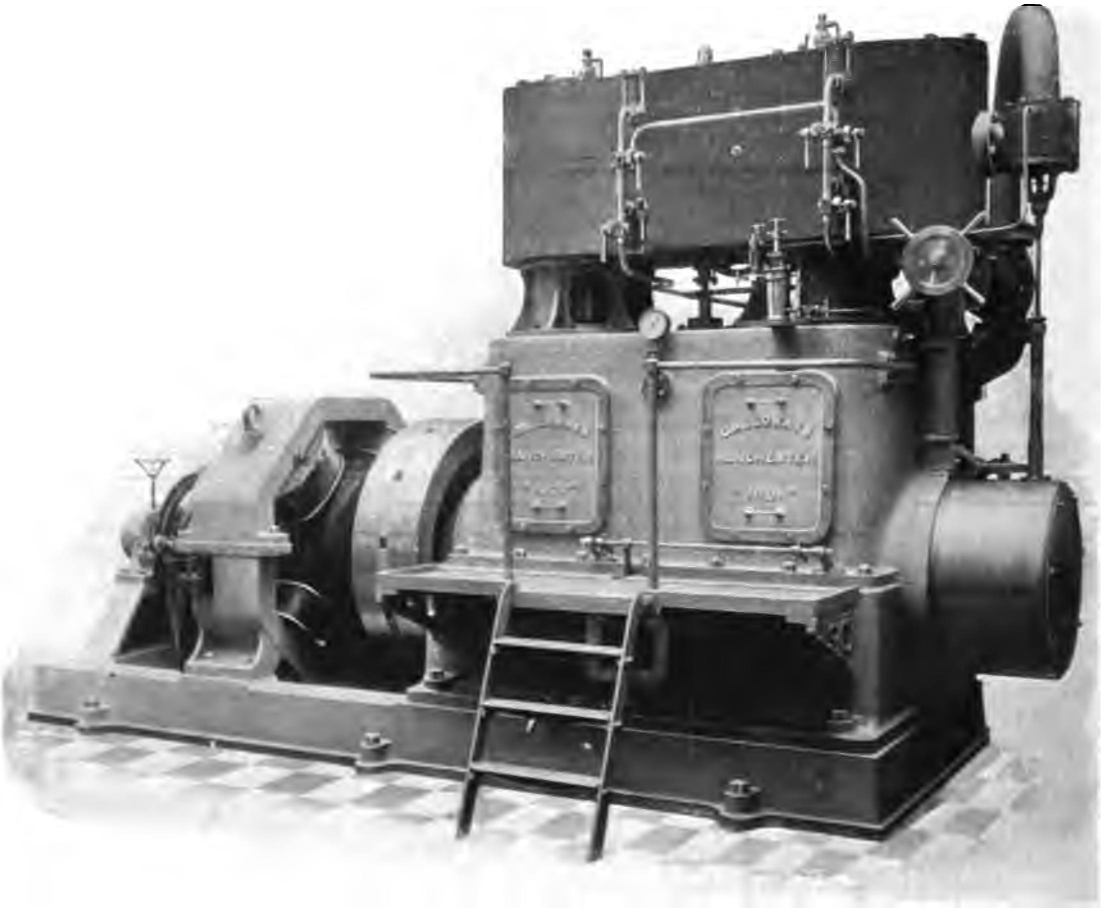

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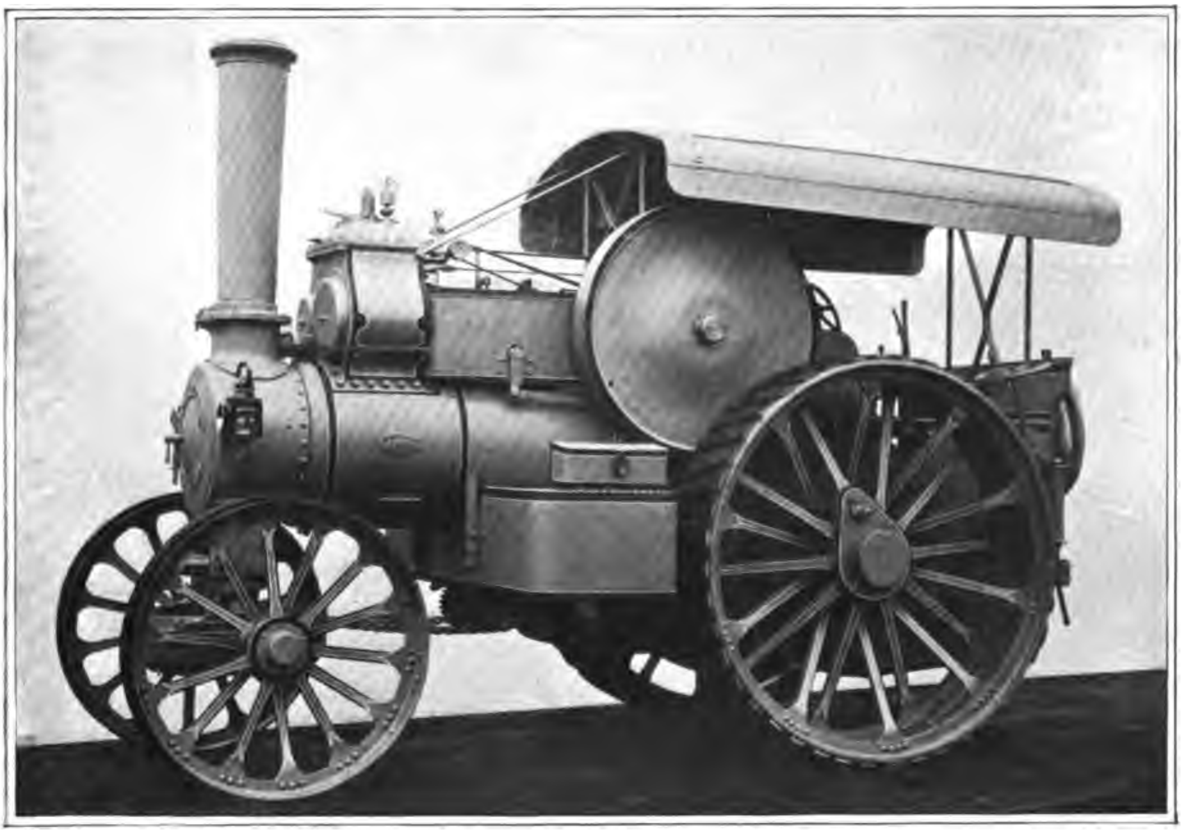

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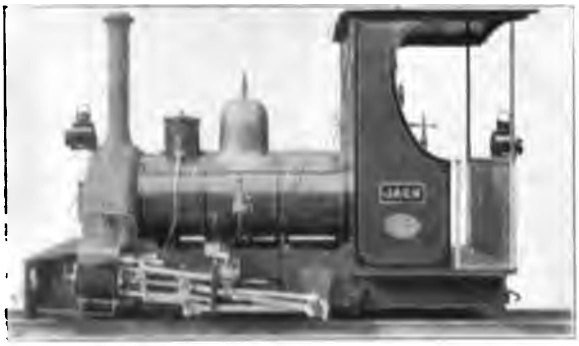

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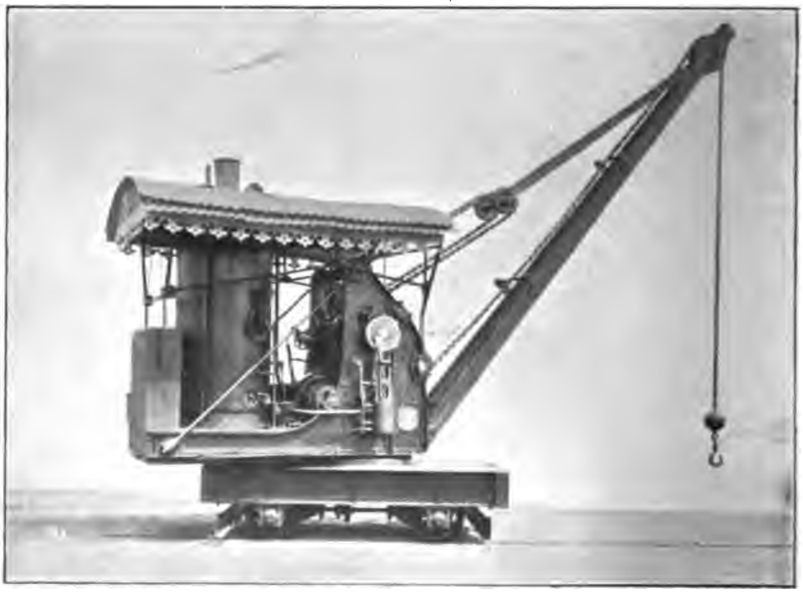

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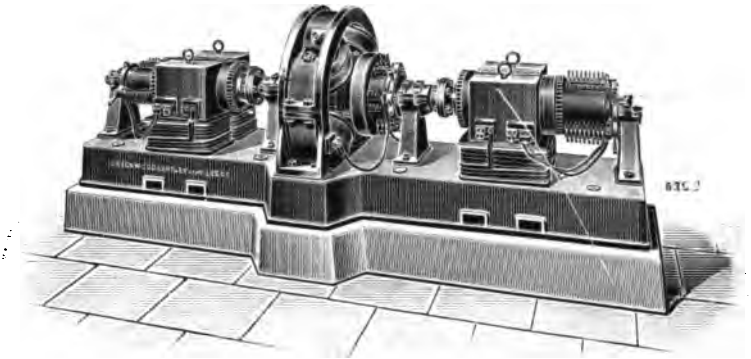

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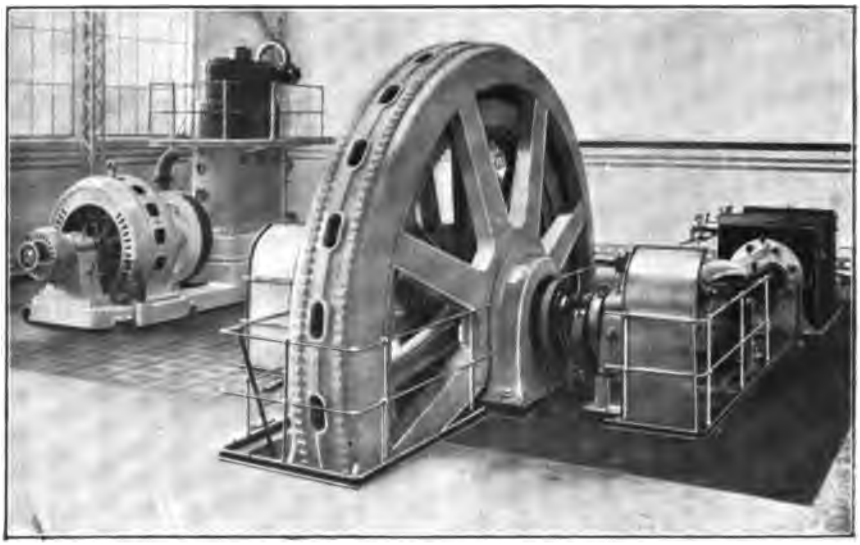

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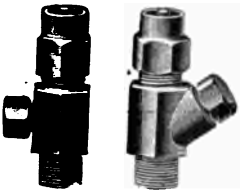

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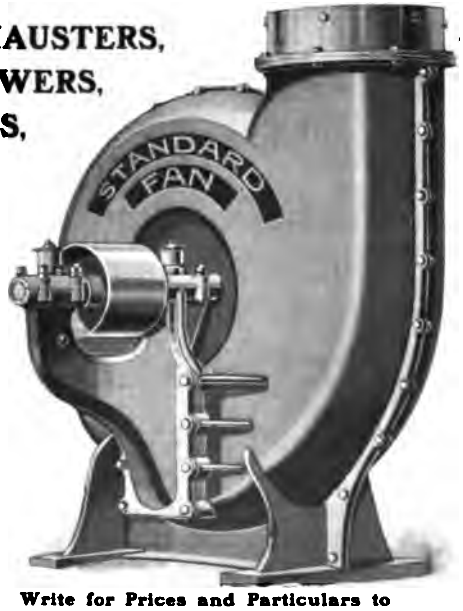

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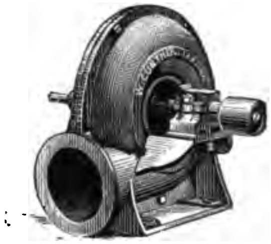

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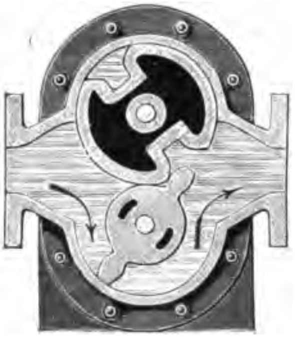

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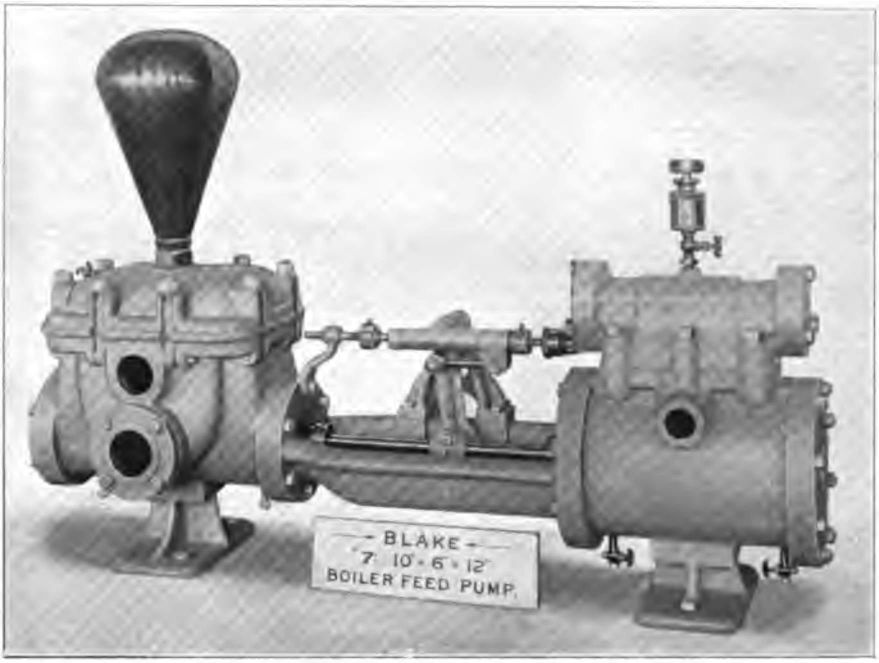

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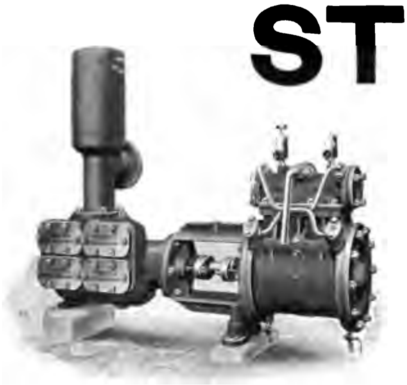

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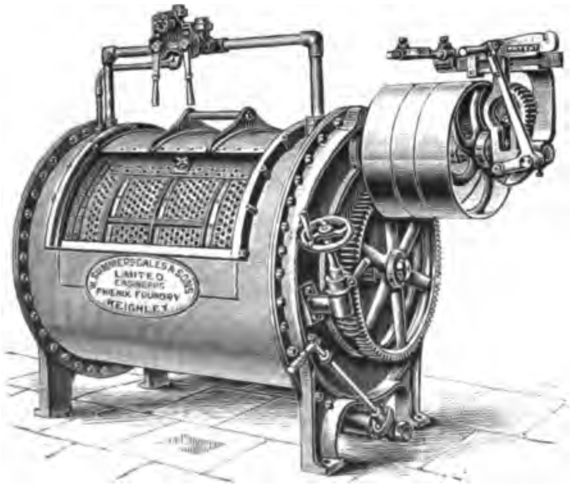

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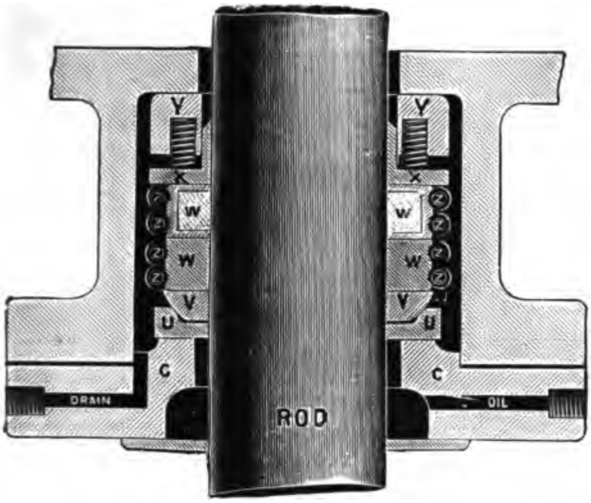

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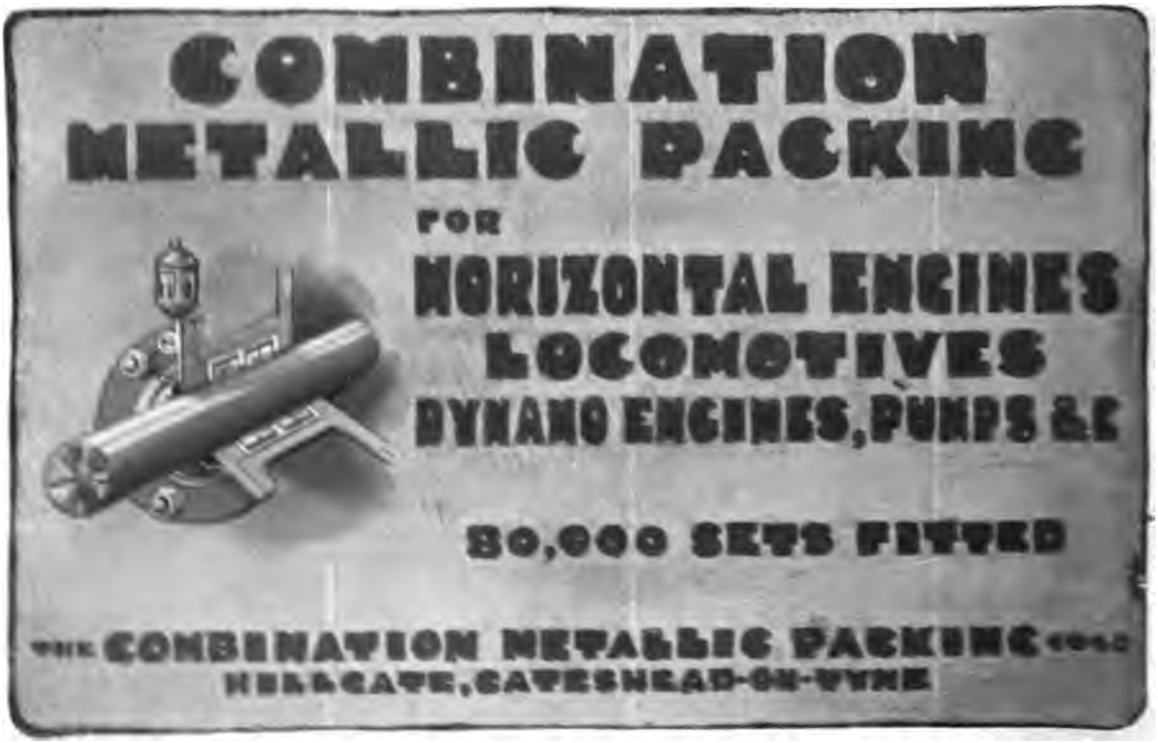

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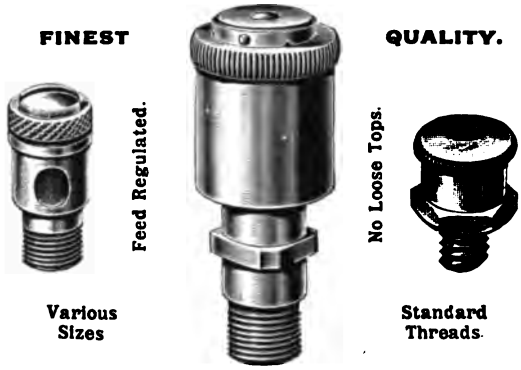
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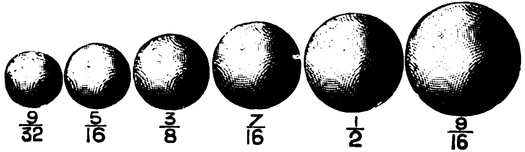

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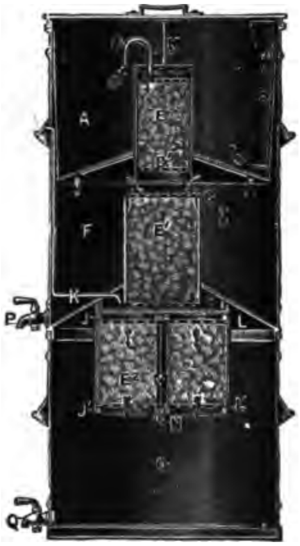

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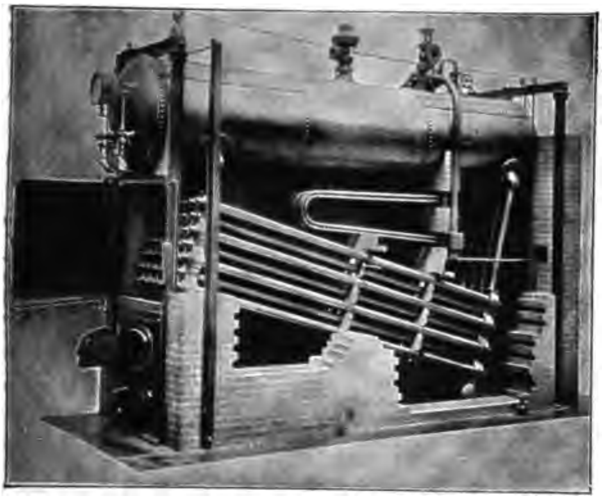

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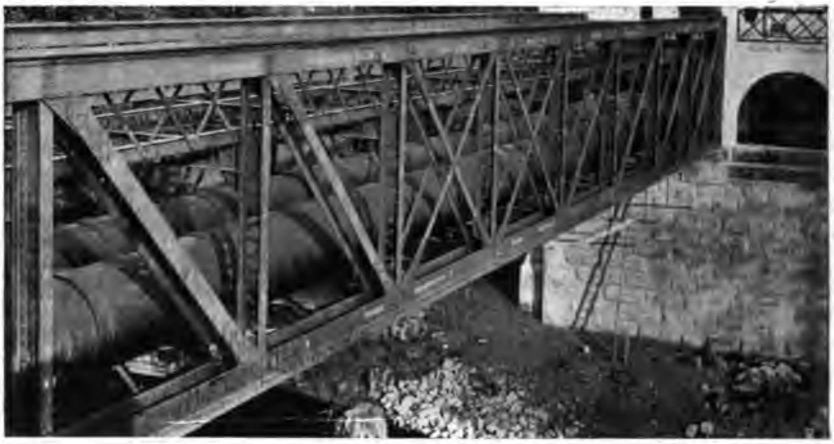

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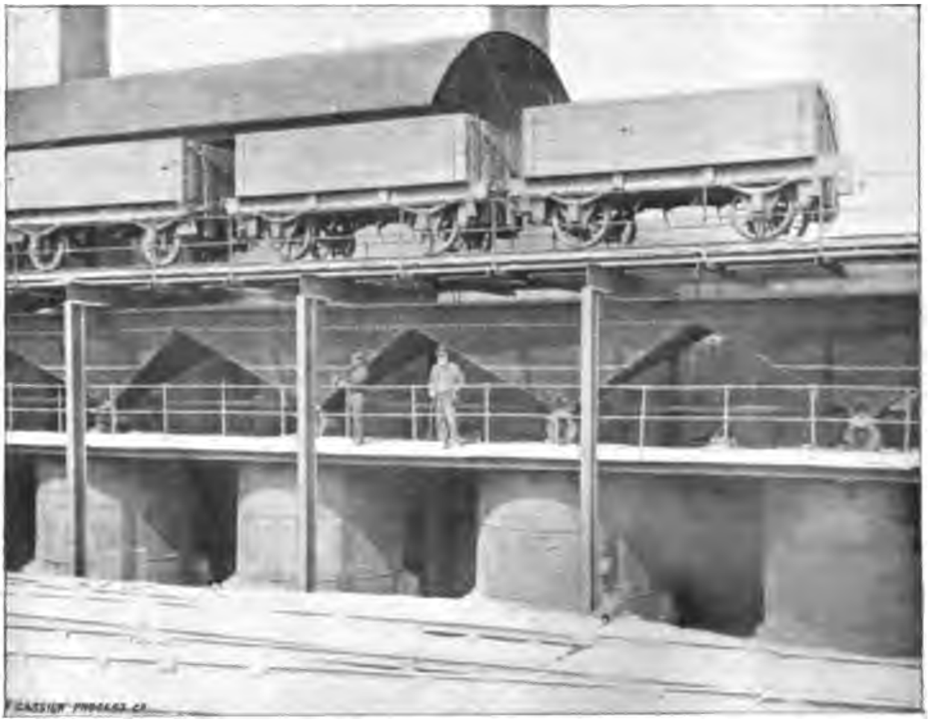

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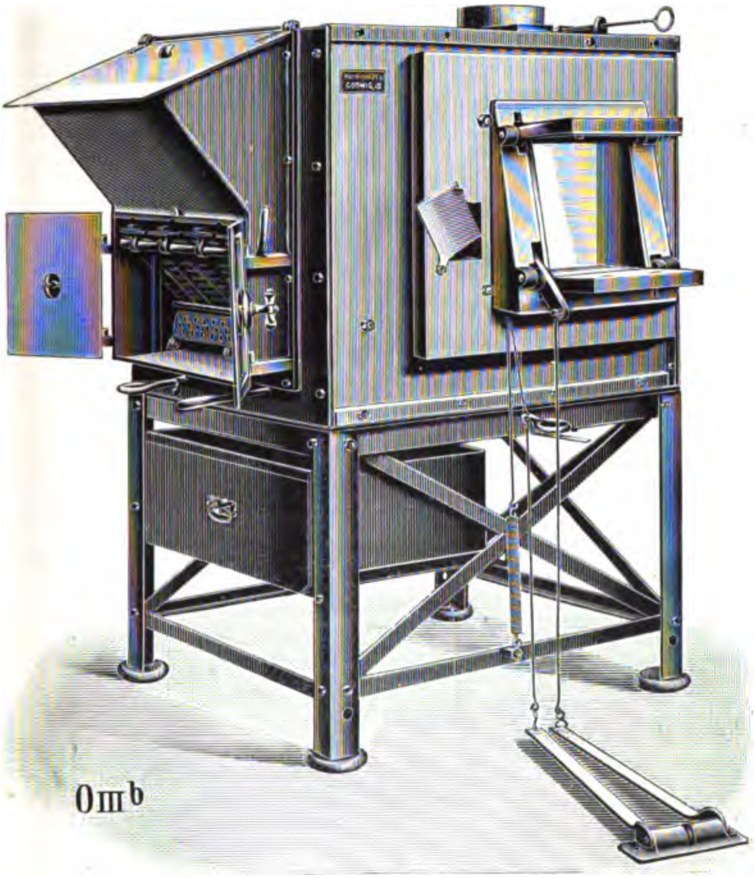

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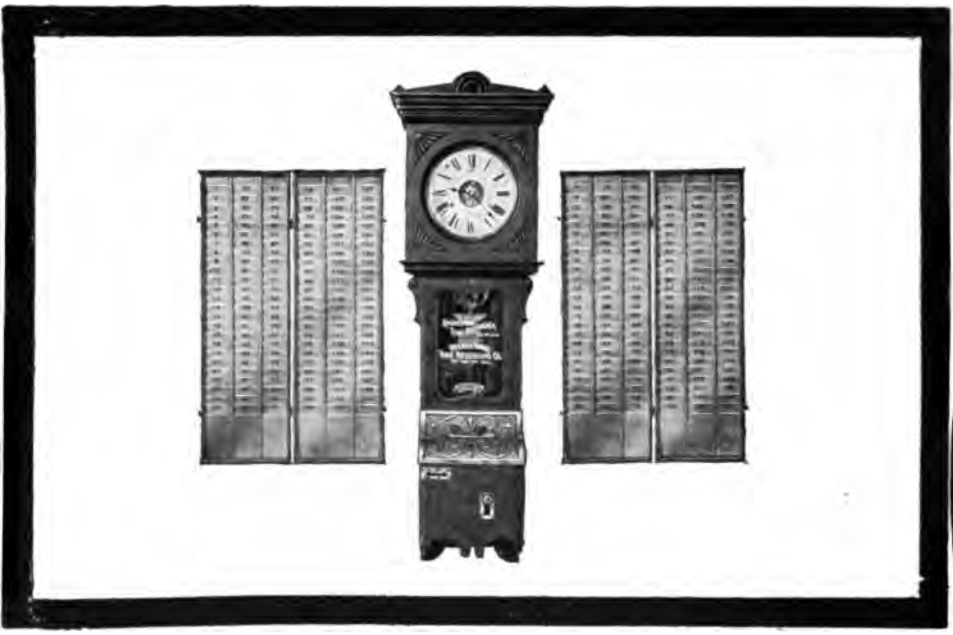

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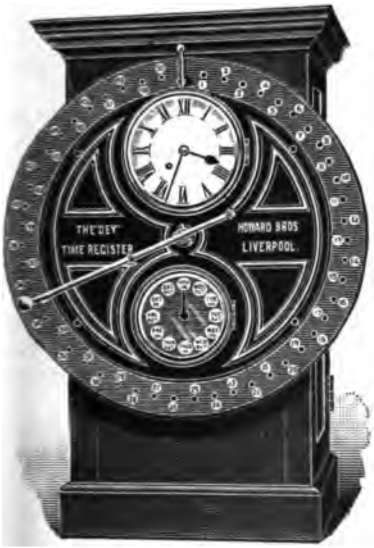

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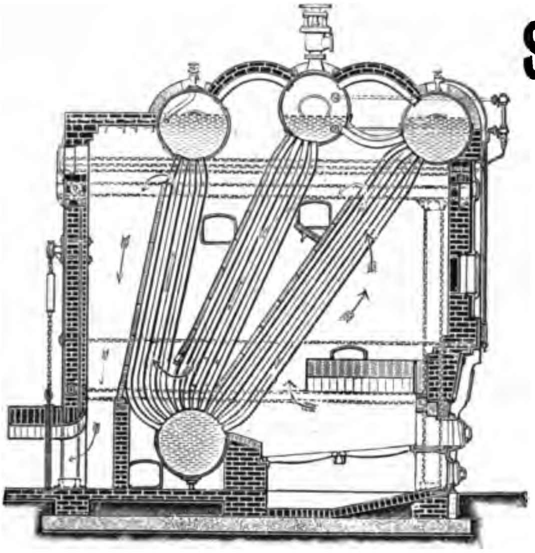

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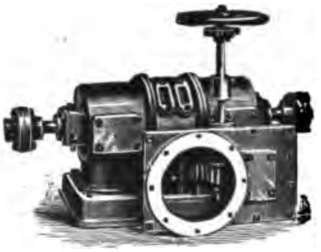

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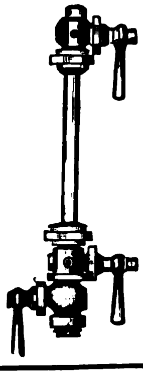

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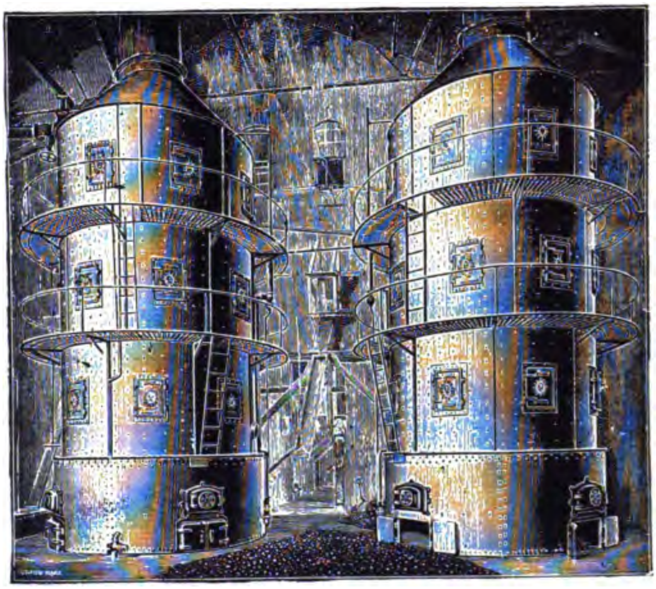

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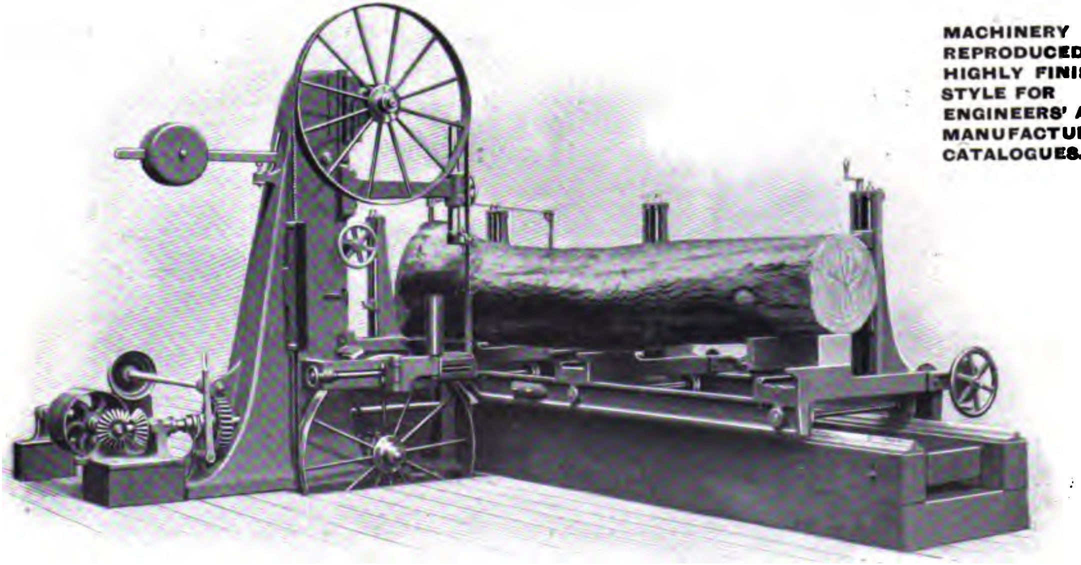

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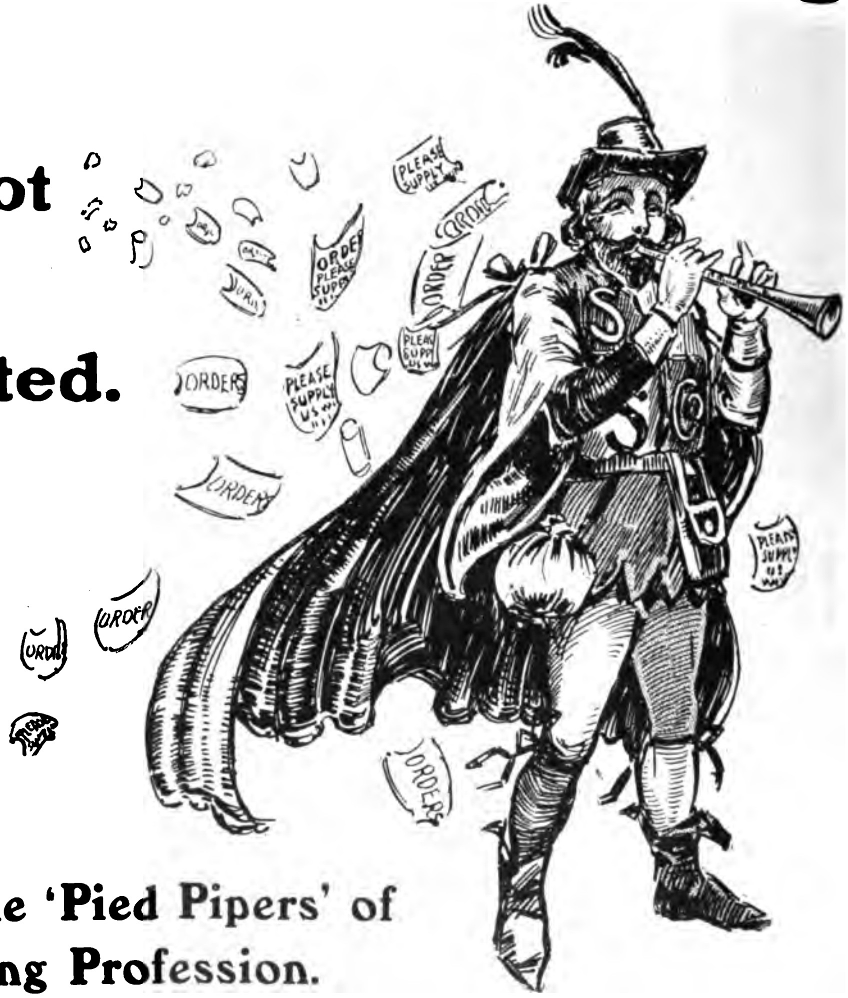

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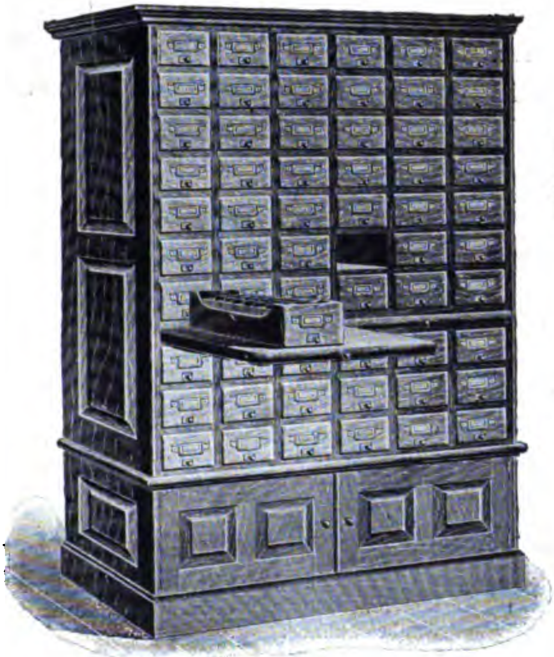

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No. 64.
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6 by 4 Cards.

No. 85.
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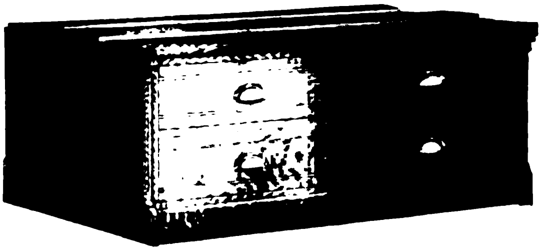

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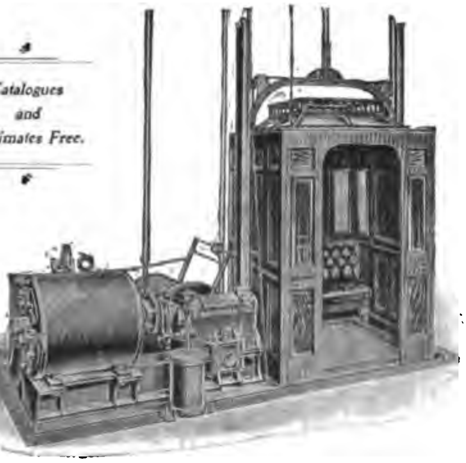

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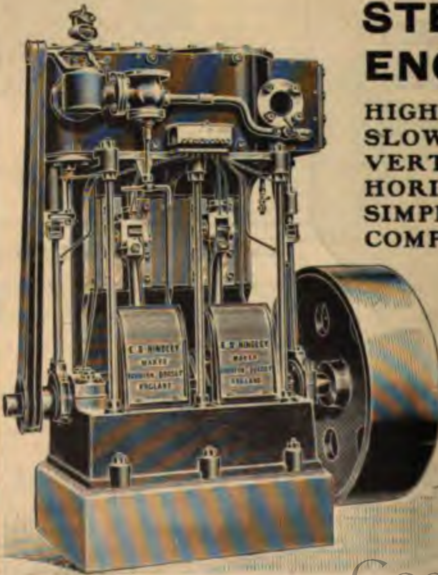
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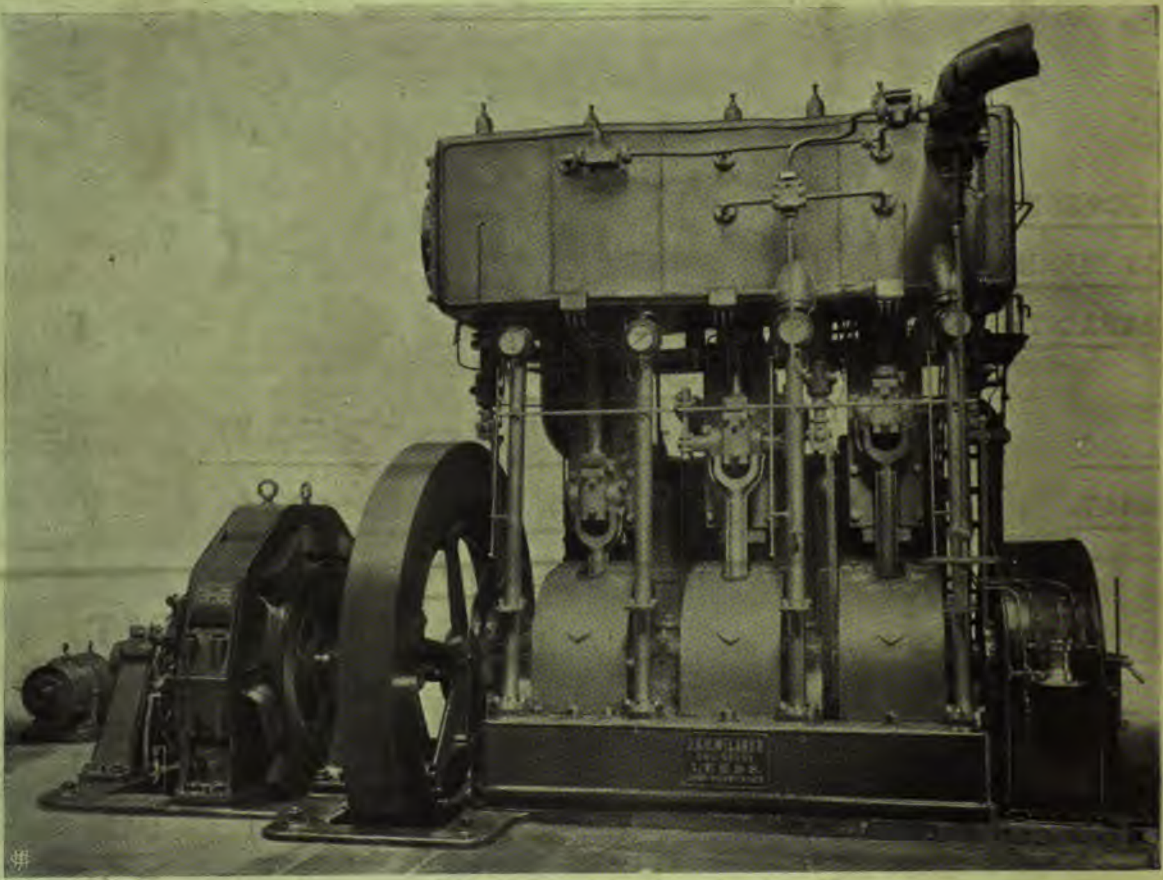

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